THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 49. Thursday, July 20, 1933. No. 883.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

Contents.

	PAGE
The Future of the Country Jobbing Foundries ...	29
Cast Metal Vital in Welding	29
Correspondence	30
I.B.F.: Visit to Pontypridd Works	30
Pig-Iron Industry in the North	30
Random Shots	30
Heat-Resisting Cast Irons	31
Catalogue Received	34
American Progress in the Use of Alloys in Cast Iron	35
Sand Testing in the Foundry	38
Pig-Iron and Steel Output	38
Company Meeting	39
This Week's News in Brief	40
Trade Talk	40
Contracts Open	40
New Companies	40
Company Report...	40
Personal	40
Obituary	40
Raw Material Markets	42

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN, THE NATIONAL IRONFOUNDING EMPLOYERS' FEDERATION, THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT: 1933-34.
C. E. Williams, "Coniston," Cefn-Coed Road, Penylan, Cardiff.

LIST OF SECRETARIES—
General Secretary: T. Makemson, Saint John Street Chambers, Deansgate, Manchester. London Office: 49, Wellington Street, London, W.C.2.
Birmingham, Coventry and West Midlands: L. W. Bolton, 21-23, St. Paul's Square, Birmingham.
Sheffield: T. R. Walker, 33, Ladysmith Avenue, Nether Edge, Sheffield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
Lancashire: J. E. Cooke, 1, Derbyshire Crescent, Stretford, Manchester.
London: H. W. Lockwood, Stewarts & Lloyds, Limited, Winchester House, Old Broad Street, London, E.C.2.
Newcastle-upon-Tyne: J. W. Eckford, 4, Mosley Street, Newcastle-upon-Tyne.
East Midlands: H. Bunting, 82, Otter Street, Derby.
West Riding of Yorkshire: S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.
Wales and Monmouth: J. J. McClelland, 12, Clifton Place, Stow Hill, Newport, Mon.
Middlesbrough: F. A. Harper, Station Chambers, Middlesbrough

National Ironfounding Employers' Federation.

President: J. Smith, Smith & Company (South Shields), Limited, Nile Street, South Shields.
Secretary: J. A. Hassal, 106, India Buildings, Liverpool.

Foundry Trades' Equipment and Supplies Association.

President: R. H. Brackenbury, 13, Victoria Street, London, S.W.1.

Secretary: K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association.

President: W. E. Clements, Morfa Foundry, New Dock, Llanelly.
Secretary: E. J. Griffiths, 2, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION.

The Registered Office and Laboratories of the B.C.I.R.A. at:—

21-23, ST. PAUL'S SQUARE, BIRMINGHAM.

Telephone: Central 1868. Telegrams: CIRA.

The B.C.I.R.A. Scottish Laboratories are:—

Foundry Technical Institute, Meek's Road, Falkirk (*Telephone 332*).

The Future of the Country Jobbing Foundries.

Being on vacation, we returned for a few hours to our tools and visited a real country jobbing foundry. Unfortunately the owner was away, and we hasten to apologise for our unheralded intrusion. The staff, which at one time numbered twenty moulders, had dwindled to one. It was casting day, and the moulder, assisted by two colleagues from the fitting shop, were taking a "breather," and received us with every courtesy. The cupola was a length of boiler tube, but had a drop bottom. The foundry itself was scrupulously tidy; the facing sand, prepared by hand, was producing an excellent skin. The castings, made wholly from scrap iron melted with good coke, were, from a superficial examination, entirely satisfactory.

The factor which interested us most was the type of work being undertaken. Without exception it was for replacements for machinery broken in service for the local industries, such as the brewery, rope works, small marine craft and the like. There was a complete absence of corporation work, such as gas and electric light standards, gully grates, inspection covers, and so forth. It was obvious that where there was time and initiative on the part of the buyers to look further afield, the local foundry was passed over. Some of the work being undertaken obviously came from the local ironmongers for new cogs for mangles and grass cutters. This too will vanish with the modern spare part service organised by the large-quantity-production foundries.

Is there a future for such small shops? Obviously they are unable to compete with the larger concerns where quantity can be a factor. They must find a speciality where the demand is such as to be too small to interest the larger establishments; a type of work which gives ample scope for old-fashioned craftsmanship and where something other than the price-factor is of paramount importance. Name plates for shrubs and trees for public parks may enter into this category. Ornamental castings for architectural work is a second suggestion. We candidly admit that the problem is difficult to solve. Yet, realising that the country jobbing foundry is an ideal place for youngsters to learn their trade, nobody deplores their present parlous condition more than we. If the larger establishments would send them their one-off jobs, they would in the long run be helping along their own industry by keeping alive these real nurseries for future craftsmen.

Cast Metal Vital in Welding.

In a recently-published Paper on some metallurgical considerations in the welding of cast irons and ferrous alloys, given to the Institution of Welding Engineers, Mr. J. G. Pearce, the Director of the Cast Iron Research Association, makes some points which are well worth attention by founders. It is pointed out that, irrespective of the process of welding used, weld metal is essentially a casting, and has the properties of a casting, made under conditions (with respect to chilling or rapid cooling, etc.), which would normally be considered to render a good casting almost impossible. It is also suggested that the properties of weld metal can never be better than those of the casting. In other words, whatever may be done to improve a weld can equally be done to improve a casting, and *vice versâ*. These comments are not made with any intention of deprecating the art of welding, which has made in recent years some remarkable advances, but nothing is gained by disguising the fact that the vital spots in a welded structure—that is, the deposits of weld metal which hold the structure together are essentially castings. The welding industry is, therefore, very keenly concerned with all developments tending to improve cast metal, particularly when deposited under the conditions under which a weld is made, and we think that it is to the interests of all concerned that founders and welders should develop technically together rather than in opposite camps. It is impossible to escape from the logic of the situation.

Some interesting points are also made with respect to the use of the recently developed austenitic irons for welding. These materials are much more readily welded than ordinary cast iron. To begin with, by virtue of their composition, the change which normally takes place on cooling in cast iron at about 750 deg. C. is entirely suppressed, and also the volume changes which go with it, both on heating and cooling. The austenitic irons are soft, readily machinable, and usually have very good corrosion-resisting properties. Most important of all, they have in the cold state a slight measure of ductility, resistance to oxidation and scaling, and they retain their mechanical properties to a very high degree at elevated temperatures.

Thank You!

Our desks have recently been enriched by the receipt of two ash trays. The earlier arrival was from August's, Limited, of Halifax. It is of plastic material, brown in colour, and is primarily intended for pipe smokers. The second is of glass, and has been sent to us by Messrs. Harris & Pearson, Limited, of Stourbridge, the well-known manufacturers of firebricks. We thank both these firms for their courtesy.

C

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Pig-Iron with Higher Manganese Content.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I should like to record my thanks to those who contributed correspondence to my article and to comment on some of the points raised.

Whilst agreeing in principle with Mr. Keeble that hypereutectic or Kishy irons can be a source of trouble, there would be no chance of this occurring in the practice I outlined. Trouble from coarse and excessive graphitisation is experienced when the iron poured into castings is hypereutectic. Assuming that as a basis pig-iron for general purpose castings an iron of hypereutectic nature is used, then with a manganese content of 1.5 per cent. minimum and a silicon content of about 3.5 per cent., a scrap ratio of from 70 per cent. to 75 per cent. could be safely carried. Under these conditions the pig-iron used would be completely refined and the resulting metal containing requisite silicon and manganese be hypoeutectic. One of the main points in my article was the possibility of employing high scrap ratios when the basis pig-iron carried sufficient silicon and manganese. Thus for this purpose a silicon content of about the figure mentioned is necessary, and the original nature of the pig-iron itself, whether Kishy or not, is relatively of minor importance.

Mr. Shepherd raises a point about sulphur pick-up from the cupola. This is a quantity which may vary greatly, according to conditions of operation and the composition of the resulting metal. It may easily rise to above 0.02 per cent., especially on a first re-melt of iron originally low in sulphur. After repeated melting the increment gained each time tends to become less. With low silicon iron necessary for malleable cast iron practice the sulphur pick-up may well be in excess of the amount quoted. In any case, as the sulphur pick-up increases so is the need for a manganese safeguard greater. The desirability of working with pig-iron of higher manganese content is thereby emphasised.

Once metal practice has been standardised on certain basis pig-irons, it is most essential that these be forthcoming indefinitely with regularity within the limits of the specifications agreed upon. Unless my experiences have been exceptionally unlucky such has not hitherto been possible. Upon occasion foreign brands of pig-iron have perforce been employed. There are signs now that the case may not be quite so difficult in the future. Apparently the great benefits to be derived from higher manganese pig-irons are becoming more appreciated. Similarity exists in this respect to the case of low phosphorus irons some years ago. At one time these, apart from hematites, were scarce and very highly priced. If, indeed, pig-iron of higher manganese content is in greater demand, it is a point of satisfaction as it reflects a more general appreciation and understanding of the effects of manganese, when used with knowledge, upon the metallurgical properties and behaviour of cast iron in all its forms.

Yours, etc.,
J. L. FRANCIS
(Chemist and Metallurgist).

Reavell & Company, Limited.
July 14, 1933.

Copper-Molybdenum Steels.—In "Cuivre et Laiton." the mechanical and welding characteristics are discussed of a steel containing 0.04 to 0.05 per cent. C, 0.01 per cent. Si, 0.45 per cent. Mn, 0.014 per cent. P, 0.13 per cent. S, 0.25 to 0.35 per cent. Cu and 0.05 to 0.07 per cent. Mo, which is claimed to be non-weathering.

Institute of British Foundrymen.

VISIT TO PONTYPRIDD WORKS.

One of the most interesting of the works visits arranged for members of the Institute of British Foundrymen who attended the Cardiff Conference was that paid to Messrs. Brown, Lenox & Company, Limited, at Pontypridd.

Brown & Lenox have been famous throughout the world for chain cables and anchors since 1803. The firm has made chain cables and moorings for every Government in the world except for Germany direct, but it was noticeable that many of the German warships at Scapa Flow had Brown Lenox anchors and cables. The founder of the company was Captain Sir Samuel Brown, R.N., who was a fellow officer of the great Lord Nelson. After retiring from active service, Sir Samuel devoted attention to the realisation of his long-cherished idea of substituting chain made of iron links for the hempen ropes hitherto used for mooring vessels. It was due solely to his enterprise and perseverance that chain cables were introduced in about 1810 by the British Admiralty for use in the Royal Navy. Chain up to 4-in. dia. iron is still welded by hand in a manner very similar to that used 100 years ago. The chief customer throughout the years has been the Admiralty, and during the Great War the firm received the thanks of the Government when the staff and workmen performed splendid feats to give necessary supplies which often could not be obtained elsewhere.

During the last 80 years the works have been extended to include smith's shops, forges, machine and erecting shops, iron and steel foundries. The steel foundry was completed in 1922 for the production of electric steel, using a 2-ton Héroult furnace, and now produces chain, cable and light sections of high quality. The romantic history of the firm is one of continual progress and of always holding the world's record in chain cables. It is interesting to record that this firm was the first to produce wrought-iron chain for ships' use, and it is also the first firm to receive sanction from Lloyd's for the manufacture of these chains in cast steel. Some of the cast-steel links weigh as much as 6 cwts. each, and entail some interesting moulding problems.

The works are situated at Pontypridd, about 12 miles north of Cardiff, on the edge of the coalfield; naturally it has always made engineering requirements for local collieries. To supply the collieries a crucible-steel foundry is still used, while the iron foundry supplies large castings such as sinkers, clumps, etc., used on moorings which Brown, Lenox & Company, Limited, are supplying to every principal harbour throughout the world.

Pig-Iron Industry in the North.

The scheme of Messrs. William Baird & Company, Limited, to modernise the Gartsherrie blast-furnace plant at Coatbridge is an unconscious criticism of the condition of the pig-iron industry in the North. There used to be 67 blast furnaces producing pig-iron in the West of Scotland. Now there are only seven. The blast furnaces in Yorkshire and Durham are often more efficient than those in Scotland. Most of them are equipped for the manufacture of gas as a by-product, produced in huge quantities by coking the coal before it is thrown into the furnace. The colossal waste of gas in the Scottish blast-furnace industry must have lost more money than it is possible to estimate. The Gartsherrie scheme, if proceeded with, will utilise the waste gases, provided a market for its consumption can be found in Glasgow and Coatbridge.

Another cause for the decline in the pig-iron production in Scotland is the intense Indian competition, developed since the war. Indian manufacturers can dump pig-iron in the Lanarkshire steelworks at prices below the local cost of production. They are assisted to do this by cheap labour and throw-away freights. Indian pig-iron can be imported into Scotland at a lower tariff than Scottish pig-iron can be exported to India.

Random Shots.

"Marksman" has noticed in the pages of the JOURNAL recently that the Editor has published a number of snapshots of foundrymen picnicing, and otherwise "on the spree." It leads him to wonder how many amateur photographers there are in the ranks of the Institute. Probably quite a number. Enough to his knowledge at least to encourage him to make a marvellously original suggestion.

* * *

You may know (and if you don't "Marksman" wishes he had headed this paragraph *Exclusive to* THE FOUNDRY TRADE JOURNAL) that the Editor at No. 49 has a quite unique collection of photographs of modern mechanised foundries. They are housed in a leather-bound and impressively-fat album, and on looking through it one has the thought that "Studies in Conveyors" would make a most apposite title for the collection. "Marksman"—unassuming as ever—has no wish to start up in direct competition, but he thinks it a good idea if someone were to make a collection of those informal snapshots which are taken at Branch outings, at the annual convention and at international conventions, and on all other occasions when foundrymen meet on "busman's holiday." Even those who don't "snap the button and let the D. & P. man do the rest," will have read about the "treasured memories in the snapshot album"—such vigorous advertisers are the camera and roll-film manufacturers. And so, "Marksman" having done his part in the good work, it remains only for some enthusiast to come forward who will be willing to carry out the actual collecting of snapshots. (If he writes to "Marksman" he can have for the asking a notable study of the largest, plumpest member of the Institute sunbathing by the sea at Blackpool.)

* * *

A firm of company registration agents has compiled statistics relating to the companies registered at Somerset House during the first six months of this year, which show that the capital involved is over £42,000,000—some £8 million more than in January to June last year and £14 million more than in the year before. "Land and buildings," of the various classes listed, attracted the largest amount—nearly £9 million. Next in monetary value were "mines and quarries" with £5 million. "Engineers" come fifth in the list, with £2,228,653, while "metals" attracted only a paltry £410,000. The largest capital for any single company was £2,640,915, the smallest £3.

* * *

HINT FOR FINANCIERS.

The Easiest Way to Form a Company.—Offer drinks all round.

* * *

The motoring offender was asked his name by the country policeman.

"John Smith," he said.

"No, your real name," snapped the constable, who had been caught the day before.

"Well, put me down as William Shakespeare."

"That's better. You can't fool me with that Smith stuff."

MARKSMAN.

Heat-Resisting Cast Irons.*

By E. Morgan, M.Sc.† (Associate Member).

Introduction.

Several Papers on this subject have at various times been presented to this and to kindred societies and the chief object of the present one is to attempt a very general review of the whole subject from the point of view of the various types of heat-resisting cast irons that have been developed in recent years. An attempt is also made to indicate how the different kinds of cast irons may be used to the best advantage after taking into consideration the varying aspects of the service conditions.

Broadly speaking, cast irons for which good heat-resisting properties are claimed fall into one of four groups, namely, certain types of white and unmachinable cast irons, used because they do not grow under the influence of high temperatures; close-grained cast irons containing low silicon and carbon contents and negligible quantities of phosphorus, corresponding with good engineering properties and sometimes having alloy additions; high silicon irons—silicon in excess of 4 per cent., of the Silal type; and the recently-developed austenitic cast irons.

At the present time cast irons which do not belong to any one of these four groups are still used extensively for purposes where the castings should be heat-resisting, a state of affairs which is due to several causes, amongst them being the fact that ironfounders are not completely familiar with the properties of the heat-resisting type of iron, or possibly, due to unfortunate results experienced where a more expensive heat-resisting cast iron has been used without a full realisation of the limitations of the iron and the conditions prevailing in a particular application. In many cases economic influences have stood in the way of a more general use of the heat-resisting type of cast iron, that is, considerations of first cost without regard to the relatively better life of irons more expensive to instal and with which fewer replacements and hence smaller replacement costs are incurred.

The strides that have been made in recent years in the development and application of materials other than cast irons demands that the industry shall be familiar with these properties. Not only is the field of application of cast iron tending to be limited by the use of the modern alloy steels (where cost does not come in as a limiting factor), and refractories, but in certain instances its use is threatened by materials which in the ordinary way are not regarded as heat-resisting. In this connection the possible use of high conductivity copper as the material for non-ferrous ingot moulds in place of cast iron is a striking example. It is claimed that the replacement of cast-iron moulds by those made from high conductivity copper not only results in a better ingot free from surface defects, which are attributed to the cast-iron mould, but that it is in fact more economical to use copper moulds on account of the longer life they have in comparison with those made of cast iron.[1, 2] This is an instance where knowledge of the recently-developed heat-resisting irons should be extremely useful in view of the fact that the irons for brass-strip moulds, as now used, are not essentially heat-resisting.

Failures of iron castings in high-temperature applications take various forms, such as fracture and/or distortion due to the severe stressing of the material; "growth," which shows itself as a large permanent expansion, and which is generally accompanied by marked distortion, and the development of small surface cracks; surface oxidation or scaling and general corrosion by the materials in contact with the castings.

It is not always an easy matter to determine the exact cause or causes for a failure, since several factors operating simultaneously may be contributing towards it. Neither is it always possible in the case of a new application to state which of the factors *which are believed to operate* (and which experience shows are not those necessarily actually operating) would have the greatest effect on the casting. As a general rule one has to judge from the observed effects produced on a trial casting—a casting which has been made from a composition which is resistant to certain well-defined conditions.

In order to consider the problem from a general point of view, the factors which require to be studied are: "growth," high-temperature corrosion and the effect produced by stresses at high temperatures. Although the conditions which promote growth, generally speaking, also produce surface deterioration through scaling, rapid growth may take place without excessive scaling, and on the other hand, as in the case of mild steels and white cast irons, rapid scaling can proceed without any tendency to grow. The two phenomena are distinct and are considered separately in order to stress the importance of the effect of external conditions on the life of castings. The fact that mild steel does not grow has not meant that this material can be used at high temperatures for the reason that it scales too rapidly. To a much lesser extent this also applies to cast irons. A grey iron which does not grow appreciably may be unsuitable because the external conditions produce excessive scaling.

Growth of Cast Iron.

The following account of this subject is given only briefly, since Papers have already been given which deal in detail with the various investigations that have been carried out, referred to in the bibliography.[3, 4, 5] In the past, grey-cast-iron castings have been employed at high temperatures with the knowledge that their useful life was considerably shortened by their liability to grow. It has also been well known that white cast irons containing no free carbon as graphite flakes and having no tendency to form free carbon when strongly heated, do not grow. Where the service conditions were such as to cause rapid growth of grey-iron castings, whenever circumstances allowed, such castings were made from white cast iron.

Although the investigations which have been carried out in the course of the last 25 years or so with the object of establishing the reasons for the growth of cast irons have not produced an iron which is absolutely immune from growth under all conditions, for it may broadly be said that where there is graphite there is liability to growth, they have, nevertheless, produced several important practical results. It is now possible to state the factors associated with the use of grey irons which affect their growth, the external conditions which promote rapid growth and the composition and properties of cast irons in which growth is only slight, even under very severe conditions.

The following description of the mechanism of the growth process, and which is based on actual experimental results, is useful in that it indicates the relative importance of the factors at work. It has been definitely established that "growth" is mainly due to the effects consequent upon the internal oxidation produced by the action of the oxidising atmosphere in contact with the iron at high temperatures. On heating from the cold, small cavities, which are due to the differential thermal expansions of iron and graphite, appear in the iron in the neighbourhood of the graphite flakes, with the result that at high temperatures any oxidising gases in contact with the surface of the casting find a ready means of access into the iron, where they proceed to oxidise the iron in the cavities near the surface. After a time the oxide layer formed on the walls of each cavity becomes sufficiently thick to stop further rapid oxidation. At this stage the internal oxidation which proceeds in this manner is virtually stopped. When the casting is allowed to cool—at a certain stage in the cooling process—the cavities near the surface become stopped up by oxide scale which consequently retards normal thermal contraction near the surface. Local stresses are set up which increase as the temperature becomes lower, and at the same time the iron is becoming increasing brittle.

A stage of the cooling process is reached when the stresses are sufficiently large to produce minute fractures which have their starting points adjacent to the graphite flakes near the edge. When cold, it is found that the casting has grown slightly—because of the presence of the oxide and the development of the small cracks. On reheating, a similar process goes on, cavities are again formed, and in addition the cracks formed during the first cycle now open out and connect with graphite flakes further in the casting. At a sufficiently high temperature oxidation proceeds in the same way as before and the cracks formed on the first heating and cooling operation become oxidised, cavities further inside also become oxidised, internal oxidation in this way proceding further into the iron. On cooling again more growth occurs, fresh cracks having been formed. Several heatings and coolings increase the effect and growth proceeds until the iron is saturated with oxide.

The development of internal oxidation, cracking and growth is facilitated by other changes which take place at the same time. Iron carbide present in cast irons, either as free graphite or a constituent of pearlite, is, generally speaking, unstable and when this compound decomposes under heat into its constituents—iron and graphite—an increase in volume is produced. Although this increase in volume is fairly small (it is 2.04 per cent. when 1 per cent. combined carbon, such as may be found in a completely pearlitic iron, is decomposed) its effect may be serious if it takes place suddenly and when the iron is brittle. The critical changes which take place when cast irons are heated and cooled within the range (0 deg. C.-800 deg. C.) are extremely important. On heating, the normal thermal expansion is arrested at the Ac. point, which may be about 750 deg. C., by a marked and rapid contraction. On cooling, normal thermal contraction is arrested by a marked sudden expansion occurring at about 720 deg. C. (Ar. point). The significance of these critical volume changes lies in the fact that they set up very high stresses in a material which is weak at these temperatures and in consequence tend to produce minute cracks in the material. These cracks aid internal oxidation and growth, in the manner described above. The effect of heating and cooling through the critical ranges is even more serious when there are large temperature gradients in the casting.

It will be clear that any unsoundness in the casting due to moulding or casting defects will also contribute in no small measure to the growth, since cavities due to unsoundness are usually far greater than graphite cavities.

Growth-Promoting Factors.

The main factors which influence growth are as follow:—

1.—*Temperature.* The rate at which grey cast irons grow increases with temperature, since the higher the temperature the larger the channels that make it possible for internal oxidation to take place. Moreover, the activity of furnace gases increases with temperature. Growth is very small below 500 deg. C.

2.—*Graphite Content and Flake Size.* The higher the graphite content and the larger the

c 2

* A Paper presented at the Cardiff Conference of the Institute of British Foundrymen.

† British Cast Iron Research Association.

size of the individual flake, the more rapid the growth. Consequently, factors affecting the amount of graphite and the size and distribution of the flakes also affect the tendency of the iron to grow. Other things being equal, an iron containing only a small amount of graphite with small flakes will not grow to anything like the extent of an iron with high graphite content and having coarse flakes.

3.—*Oxidability of the Iron.*—The more easily the iron is oxidised, the more rapid the growth. Consequently elements present in cast iron which increase its resistance to oxidation also increase its resistance to growth.

4.—*Ductility at Low Temperatures.* The more ductile the iron at temperatures approaching air temperature, the less liable the iron is to develop cracks due to the local stresses imposed by the presence of internal oxide, and therefore the less is the tendency to grow.

5.—*Strength at Temperatures in the Neighbourhood of the Critical Points.* The stronger the iron at temperatures between 700 and 800 deg. C., the smaller the effect produced by the volume changes at the critical points.

6.—*Stability of Combined Carbon.* Irons containing combined carbon should be made stable for work at high temperatures. Elements which increase the stability of combined carbon increase resistance to growth. In ferritic irons—containing little or no combined carbon—this does not arise.

7.—*Dissolved or Occluded Gases.* There is evidence for believing that gas-free irons resist growth better than irons containing much gas in solution.[6]

Fundamental Requirements for Non-Growth Grey Iron.

A grey cast iron which is to be, relatively speaking, non-growing should have the following characteristics:—Low graphite content, finely-divided graphite flakes, resistance to oxidation, ductility at low temperatures, and a certain degree of strength at temperatures where critical volume changes occur, although it is preferable that critical temperatures should not be present in the working temperature range. If combined carbon be present, it should be stable. Actually, it is difficult to obtain a cast iron possessing all these attributes, but fortunately the relative importance of these properties depends very largely on the external conditions, so that it is possible to select irons which on account of the external conditions prevailing, are the most suitable from the point of view of growth. Other considerations besides growth have also to be studied, as will be shown later. As a result of much experimental work, cast irons which grow to the least extent when subjected to fluctuating temperatures in oxidising atmospheres are found to fall into one of the four main groups already indicated.

Group 1.—White Cast Irons.

White cast irons contain no graphite flakes and when the composition is such that the combined carbon is stable at high temperatures, no growth results when the iron is repeatedly heated and cooled, but there is a tendency to develop cracks by reason of its brittleness. An iron with the following composition: Total carbon 2.66 per cent., silicon 0.587 per cent. and manganese 1.64 per cent., was found to be immune from growth at 900 deg. C.[4] In spite of the fact that white irons do not grow, their application is limited on account of their brittleness and also because of the rapidity with which they scale even under mildly oxidising conditions. This is referred to later.

Group 2.—Low Silicon Irons.

These irons include what may be termed the conventional grey irons, containing up to about 1.2 per cent. silicon and about 3.2 per cent. carbon and having a fine close-grained structure. Irons of this type are strong and possess some ductility at low temperatures, but they suffer from the disadvantages associated with critical points occurring at fairly low temperatures (700 to 750 deg. C.) and on this account should not be employed at temperatures above 700 deg. C. since the volume changes at the critical points have a very serious effect on the growth. Irons developed from these by alloy additions are superior to them in their resistance to growth, due to the presence of small quantities of chromium, up to about 0.5 per cent. The difficulties which attend the use of chromium, such as hard spots and brittleness, can be eliminated materially by the use of nickel in small quantities with the chromium. Hot-mould irons also belong to the low-silicon class, as their silicon is unusually low, but they are not suitable for use at high temperatures in excess of 700 deg. C. because of the presence of the critical points and also because they generally have rather large graphite flakes which make them prone to internal oxidation. All these low-silicon irons have the advantage over other types of heat-resisting irons, of being easy to make into sound castings, and which stand rough usage. On the other hand, they oxidise readily, so that where oxidising conditions are severe they fail quickly. Small variations in the amounts of the elements usually present in cast irons, such as manganese, sulphur and phosphorus, have no appreciable effect on the tendency of these irons to grow at high temperatures, and the limits within which they may vary depend more upon the effects such variations would have on the casting properties, soundness, strength, etc., than on growth. The amount of phosphorus which can be usefully employed depends upon the local conditions. Below 900 deg. C. phosphorus actually keeps the iron rigid through the network of hard phosphide eutectic. Above this temperature it rapidly becomes plastic and the iron may collapse. The lower the phosphorus the greater the ductility and hence less the liability to cracking through repeated heating.

Group 3.—High-Silicon Irons.

Irons in this group developed by the Association and covered by British Patent 323076, and known by the registered trade mark "Silal," contain from 4 to 10 per cent. silicon and have a ferrite: fine-graphite structure, and are growth-resisting for the following reasons:—(1) Low carbon content yielding small graphite content and fine-graphite structures, giving maximum protection to gas penetration; (2) resistance to oxidation, due to the high silicon contents, and (3) the positions of the critical points can be raised beyond the maximum service temperature by the use of sufficient silicon.

A fine-graphite structure is essential since irons of this composition containing coarse-graphite structures permit gases to enter, and when the carbon content is high, together with coarse graphite, they grow even more rapidly than common irons at 900 deg. C., as shown by Carpenter and Rugan.[7] The effect of the silicon on the position of the critical points is shown by the following figures:—

Percentage carbon	2.56	2.54	2.49	3.10	2.11
Percentage silicon	2.03	3.43	4.46	5.64	7.58
	deg.C.	deg. C.	deg. C.	deg. C.	
Critical points Heating	760	800	875	935	absent
Critical points Cooling	685	740	810	920	

In any application the actual silicon content is determined by the temperature, the higher the temperature, the higher the silicon content. Since the higher the silicon content, the weaker and more brittle the irons, it follows that the minimum silicon content necessary to prevent growth should always be used. The lack of ductility which is characteristic of these high-silicon irons is a serious obstacle to their adoption for heat-resisting purposes such as in engine practice. The importance of ductility at low temperatures has already been stressed in the discussion of the mechanism of "growth." It is so important that a small amount of internal oxidation in a brittle iron can be more serious from the point of view of producing growth in the iron than a much greater amount of internal oxidation in a non-brittle iron. Consequently a high-silicon cast iron that is used at temperatures which are higher than should be applied to an iron of that silicon content may fail more rapidly than a common iron. Examples of this have been afforded where Silal irons have been made into firebars which have been heated nearly to their melting point, with consequent short life. Where failure takes place in a common iron, the growth and deterioration is relatively progressive, but with high-silicon irons wrongly applied, failure can take place rapidly.

In using such irons for purposes where a non-growing iron is required, less latitude is allowed regarding composition and structure than in the case of low-silicon irons. The silicon content must be that which produces a certain margin of safety and the graphite structure must be extremely fine. Experiments which have been carried out in the Association's laboratories show that when aluminium is also present to the extent of 2 per cent. or more, as covered in the original patents, high-silicon irons are markedly improved. There is good ground for thinking that when aluminium is present the danger from sudden failures is much reduced, but there is considerable difficulty at the present time in making sound castings containing aluminium in these proportions. When, however, this difficulty is surmounted there is no question that high-silicon irons will find much wider application than they have at the moment.

Group 4.—Austenitic Cast Irons.

Austenitic heat-resisting cast irons are best obtained by the use of the correct amount of nickel, and the first benefit which results from the conversion of pearlitic irons to austenitic irons is that the critical points are absent at temperatures above room temperatures. Generally speaking, in developing austenitic irons to withstand any tendency to grow, the idea has been to make the austenitic matrix resistant to oxidation and at the same time stable under varying temperature conditions. The total-carbon content is low and the graphite fine. At the present time there are two types of austenitic-nickel cast irons, namely, the low-silicon type developed independently by Arnott in this country, and by Vanick and Merica in U.S.A.,[8] and known respectively as Nimol and Niresist, and the high-silicon austenitic irons known under the registered trade mark Nicrosilal,[9] British Patent 378508, developed by the British Cast Iron Research Association. The compositions given for Niresist are:—Total carbon, 2.75 to 3.10; silicon, 1.25 to 2.00; manganese, 1.00 to 1.50; nickel, 12 to 15; copper, 5 to 7, and chromium, 1.5 to 4 per cent.

The chief difference between these two types of irons is the higher silicon content of Nicrosilal, which may be as much as 6 per cent., and the absence of copper, and for this reason the latter offers a greater resistance to scaling and growth than Niresist. The presence of chromium, besides having the important effect of stabilising the structure also improves the resistance to oxidation and aids in the production of a fine-graphite disposition due to the formation of chromium carbide. Austenitic irons are very ductile at room temperatures. Even the high-silicon irons are ductile when austenitic, and more than 1-in. deflections are obtained with 1.2-in. bars on a 14-in. span when broken in transverse. Details of the various compositions and the properities of these austenitic irons are given in the Papers referred to above[5, 8] and consequently will not be dealt with here. It may be pointed out, however, that from tests carried out a Nicrosilal iron containing total carbon 1.8 per cent., silicon 6 per cent., manganese 1 per cent., nickel 18 per cent. and chromium 2 per cent. had practically no tendency to grow even at 900 deg. C. in the presence of moist CO_2, making a strongly oxidising atmosphere. Under the same conditions an iron in Group 2 had grown to about 20 per cent., and the Silal type of iron containing 5 per cent. silicon, about 3 per

cent. The non-growing property of such an iron is not surprising when it is considered that it has all the characteristics listed above required of a non-growing iron.

Reviewing the position regarding growth, it will be seen that after white unmachinable irons, which do not grow, austenitic irons, especially the high-silicon type, come next in order of merit and the choice of one or other of the low-silicon and the high-silicon irons rests entirely on the service conditions. If they are severe and above 700 deg. C., irons of the Silal type should be used, provided the right composition is chosen and the rate of heating or cooling is not such as to make the lack of ductility a serious matter. On the other hand, when the temperatures are below 700 deg. C. and the conditions are not seriously oxidising, the low-silicon type of iron is to be preferred for the reasons given.

High-Temperature Corrosion.

In order to function properly at high temperatures, present-day conditions of service often demand a high degree of resistance on the part of castings to the various corroding media which may be in contact with them. Such media may be solid, liquid or gaseous and may be chemically oxidising or reducing. Often matters are complicated by continual changes in the conditions, and sometimes it happens that a casting is acted upon on one surface by influences essentially oxidising, whilst the other side is in contact with substances chemically reducing. In the most common applications, however, oxidising atmospheres only are met, and the problem of obtaining a material which does not scale under these conditions is practically solved when the iron is such that the tendency to grow is only small. This is true of grey-iron castings, but not of low-silicon white irons. The latter can be made resistant to oxidation by the use of chromium in sufficient amounts. The work of Valenta[9] and others has shown that in order to be immune from oxidation the chromium content should exceed 15 per cent. No further improvement is obtained by using more than 35 per cent. chromium. The carbon content of these high-chromium white irons may go up to 3.5 per cent., but high-carbon irons have a tendency to give brittle, heterogeneous castings and so it should not be too high.[10]

In the case of low-silicon irons which are readily oxidised at high temperatures in the presence of strongly-oxidising gases, a small improvement is possible by the use of chromium, but the amount of chromium that can be used without causing the iron to become hard and unmachinable is relatively small, so that consequently the improvement is not very pronounced. Attempts have been made to render the surface immune from oxidation by nickel plating, but it is found that the metal coating breaks up after a few heatings, due to the volume changes occurring in the iron.[4] Silicon and aluminium have very beneficial effects with regard to scale-resistance, and on this account high-silicon irons and the high-silicon austenitic irons have a remarkable degree of resistance. The manner in which oxide scale forms and the functions of such elements as chromium, aluminium and silicon in forming a resisting oxide film are dealt with by Pfeil.[11]

Possibly the most serious factors in high-temperature corrosion are sulphur and its compounds, and matters are not by any means improved by the presence in most furnace atmospheres of high-moisture contents. The following figures (Table I) for compositions of various gases given by Hatfield[12] illustrate this point.

Failures of castings as a result of excessive scaling in atmospheres containing sulphur compounds are common and analyses of this scale show that it contains a high percentage of sulphur. As much as 15 per cent. of sulphur was obtained on the scale of a casting which had been in service for only a comparatively short time. Under purely oxidising conditions the thin oxide film protects the metal from further oxidation, but when sulphur compounds are present the film is not by any means protective, although it may be made more so by well-recognised methods. Silicon, chromium and aluminium, besides improving resistance to oxidation, also tend to keep sulphur attack within limits. The following figures (Table II) obtained by heating various cast irons in a gaseous mixture containing 77.5 per cent. moist CO_2 and 2.5 per cent. SO_2 for four hours at 900 deg. C. show clearly the important effect of silicon.

TABLE I.—*Incidence of Sulphur in Industrial Gases*

	Per cent. by volume					
	CO_2	CO	O_2	H_2O	SO_2	N_2
Gas in unenclosed muffle	4.8	5.1	1.3	21.0	0.003	67.7
Products of combustion from coal-fired furnace	10.7	nil	6.1	4.5	0.04	78.7
Products of combustion from annealing furnace	15.7	—	nil	6.6	0.06	77.7
Products of combustion from Siemens furnace	13.3	—	3.44	12.2	0.1	70.95

The beneficial effects of chromium and aluminium have been amply confirmed by investigations on heat-resisting steels.[13, 14] In order, therefore, to be able to resist the action of oxidising gases containing sulphur compounds, one must be prepared to use high contents either of chromium, silicon or aluminium in the castings. With regard to reducing conditions, and especially when sulphur is present, there is no cast iron or steel which can withstand these conditions at high temperatures for any length of time.

In addition to gases, there are also applications where castings are in contact with molten salts and metals and with other materials. Some of the applications involving contact with such substances are considered later.

TABLE II.—*Influence of Silicon upon Scaling*

Total carbon, per cent.	2.8	3.8	3.4	2.9	1.8	2.4	3.1	1.8	1.1	0.9
Silicon, per cent.	0.7	1.6	2.5	2.8	5.4	5.5	5.6	9.1	11.6	15.3
Percentage increase in weight	2.62	2.25	3.28	2.58	0.04	0.07	0.06	0.06	0.03	0.02

Stresses at High Temperatures.

Generally speaking, the most important stresses at high temperatures, and those which are responsible for the greatest number of failures through cracking of the castings, are thermal stresses which are due to the thermal expansion of the metal, and which are intensified by carelessness in heating and cooling, unequal temperature distribution, or when steep temperature gradients are present. Although in many applications the causes which give rise to intense thermal stresses in the castings can be avoided by correct design and proper treatment of the casting in service, there are many instances where these conditions are inseparable from the type of service. It is, therefore, of the utmost importance to seek the cause of these high stresses and to determine whether it is possible to obtain compositions in which their effects are reduced. Thermal stresses produce grave distortions in ductile materials such as mild steels and produce fractures in brittle materials. A material to withstand these thermal shocks must have a ductility and strength somewhere intermediate between these two extreme cases if distortion is to be minimised. No actual figures are available regarding the ductility required, but experience with certain applications indicates very clearly the order of this ductility.

The strains produced by these stresses are naturally concentrated in the cooler part of the casting, and, since this is the most brittle part, it is also the part of the casting liable to break. Cantilever tests carried out by the British Cast Iron Research Association demonstrate clearly how the ductility increases with rise in temperature. Even extremely brittle irons bend readily without fracture under loads at 850 deg. C. Close-grained irons, even when the silicon content is low, are liable to this type of shock, and high-silicon irons, as pointed out before, are still more liable. Medium-silicon irons of hematite composition containing about 3.5 per cent. total carbon and about 2.0 per cent. silicon can withstand these conditions fairly well, as evidenced by the remarkably good performance of steel ingot moulds, which are almost invariably made from hematite, and this property is attributed partly to the coarsely graphitic nature of these irons and to their uniform pearlitic matrices. Austenitic cast irons can withstand thermal stresses without cracking remarkably well, provided that the right composition is chosen.

It is a fact that many of these austenitic irons are more suitable at temperatures in excess of 800 deg. C. than they are at temperatures below this figure, as they tend to undergo constitutional changes which render them brittle when maintained at certain temperatures for any length of time. It is not possible in this Paper to discuss the compositions which are stable at all temperatures, and for details concerning them it is necessary to refer to a Paper already mentioned.[5] It may be pointed out also that many of the nickel-chrome heat-resisting steels cannot be used where low-temperature conditions are likely to be present, as even these materials develop intercrystalline brittleness.

Stresses which are the direct consequence of thermal expansion, other conditions being constant, naturally increase in intensity as the thermal expansion coefficient increases. With regard to pearlitic and ferritic cast irons, there is not much scope for varying the composition in order to diminish the thermal expansion coefficient except in so far as mottled irons, and especially those containing small proportions of nickel and chromium, are concerned. Practically all grey cast irons which are pearlitic or ferritic structurally have a coefficient which is of the order of 1.4×10^{-5} and this coefficient is fairly constant up to the critical points. In mottled irons the expansion is not constant over this range of temperature. The value of the coefficient is less than 1.4×10^{-5} below 200 to 300 deg. C., and higher above this range. The consequence of this discontinuity in the expansion is that mottled irons are more prone to thermal shock than soft irons.

The thermal expansion coefficient of austenitic cast irons is 1.8×10^{-5}, and consequently such irons expand more rapidly than pearlitic irons. For this reason temperature stresses will be higher in austenitic cast irons. Temperature gradients are steepest in cast irons with low thermal conductivities. Donaldson[14] finds that silicon considerably lowers the thermal conductivity. Nickel, and also manganese and vanadium to a lesser degree, have a similar effect. Chromium and tungsten tend to raise the conductivity. Consequently thermal stresses will be higher in castings made from high-silicon cast irons than they would be in castings made from low-silicon irons. Austenitic irons have still lower thermal conductivities, being approximately two-thirds of that of a low-silicon iron.

Distortion and sagging of castings from the same source and also under their own weight, or when actually carrying loads at high temperatures, are also extremely troublesome. For this reason castings should be as rigid as possible at the working temperatures. The Association is actively engaged in carrying out tests to discover the degree of rigidity possessed by cast

irons of various compositions at different temperatures, and it is hoped to have these results at an early date. The question of rigidity at various high temperatures has been examined in several ways.[15] Smalley has published results obtained by means of the short-time tensile test on grey cast irons of various compositions.

A typical grey iron containing about 3.0 per cent. total carbon and 2 per cent. silicon, having a strength of nearly 18 tons in the cold, was appreciably weaker at 250 deg. C. with 15 tons, but its original strength was restored at 400 deg. C. At 600 deg. C. the iron broke under a load of 9 tons per sq. in., and at 850 deg. C. a load of only 2 tons per sq. in. was sufficient to fracture a similar iron.[16] Donaldson shows that the fall in strength at 300 deg. C. may be eliminated by annealing.[17] According to Bolton,[15] the main criticism of the short-time tensile test lies in the fact that no time is allowed in carrying out the test for certain constitutional changes, which affect the strength, to take place, and for this reason Donaldson's tests on annealed specimens are of more value than tests on specimens in the as-cast condition.

The long-time tensile or creep stress is more conclusive, but until recently little had been done in the way of applying this test to cast irons. Honegger[18] shows that the creep of certain cast irons, even under a load not exceeding about 5½ tons per sq. in., is quite pronounced at 400 deg. C. The Association has studied creep under bending stresses and some valuable results have already been obtained. The tests show very clearly that the higher the silicon contents of cast irons the stiffer they become at 850 deg. C. Austenitic irons are even more rigid at these temperatures. For example, a high-quality iron containing total carbon 3.3 per cent. and silicon 1.25 per cent. had deflected 1.9 in. in a test of four days' duration at 850 deg. C., an iron containing total carbon 2.15 per cent. and silicon 6.65 per cent. deflected by 0.325 in. in the same time and under a similar load, whilst an iron containing nickel 18 per cent., chromium 2.0 per cent., silicon 6 per cent. and carbon 1.2 per cent. had deflected only 0.8 in. under exactly similar conditions.

APPLICATIONS.

In this section of the Paper are considered some problems which arise with certain applications. The few samples considered have been chosen because they show the diversity of the conditions of service and the factors that have to be considered.

Furnace Parts.

Conditions inside industrial furnaces vary remarkably; at one end of the scale are the medium-temperature electrically-heated annealing furnaces, with neutral or mildly-oxidising atmospheric conditions, and at the other end of the scale, high-temperature furnaces, coal, coke, gas or oil-heated, where the atmospheric conditions are very corrosive in their effect upon iron castings. For this reason it is entirely out of the question to make general recommendations. For each type of furnace the temperature, duration of heating, method of heating, type of fuel, atmospheric conditions inside the furnace, and loads, if any carried by the casting, are the factors that have to be carefully considered.

Firebars and Stoker Links.

The problem with regard to firebars and stoker links is an interesting one. Actually, the average temperature attained by such castings in service is quite low, but very high-surface temperatures may be reached, and sometimes they are high enough to cause incipient melting of the castings. Obviously, when such conditions are unavoidable, cast iron will not stand the service for long, and it is, therefore, often a matter of choosing the cheapest material and replacing the castings as soon as they fail. For this reason high phosphoric, medium-silicon cast irons are used extensively, and where machinability is not necessary and the design is simple, firebars are made from white cast irons. In many instances the high temperature on the face of the bars is due to the type of coal used, since certain coals have a tendency to develop intense local heating. The ash content of the coal is also important, especially when the sulphur content is high, as it has a very marked corrosive effect on cast irons. Where the right type of coal is used, the employment of low-silicon, low-chromium cast irons have very decided advantages, and excellent results have been obtained by the use of high-silicon Silal irons. The use of austenitic cast irons is not generally possible on account of their high initial cost, but where they have been applied, excellent results have been obtained.

Carburising Boxes.

Carburising Boxes.—The material used in carburising boxes must be capable of withstanding the effects of heating to the carburising temperature (780 deg. to 900 deg. C.) in the presence of the products of combustion of the fuel used for heating the furnace, followed by cooling down to ordinary temperature, without cracking, distorting, growing, or showing excessive corrosion. The last item is progressive and is consequently not so important as the others, which may manifest themselves after only one or two heating cycles. In addition to the above, the possible effects of the contents of the carburising box have to be considered. Various types of case-carburising mixtures are in use, varying chiefly with regard to the sort and amount of "energiser" present in them. The presence of the salts of sodium, barium and calcium in the energiser has a very harmful effect on ferrous materials. It is, therefore, not surprising to find that the data regarding the usefulness of various types of materials used for carburising boxes is very inconclusive. Nickel-chrome alloys are used extensively and generally with good results, but even with the use of such materials apparently unaccountable failures are experienced, due generally to the type of energiser used. Of the cast irons available the most promising are austenitic irons, since the service demands a certain amount of ductility. The author understands that a Nicrosilal with about 3 per cent. chromium is giving very good results.

Metal and Salt Pots.

Cast irons are used extensively for metal and salt pots. Of the metals used, probably the tin-antimony alloys and zinc have the most serious effects on cast irons. One gathers from the literature that even nickel-chrome steels are not capable of withstanding the action of these metals for long periods. With regard to molten aluminium, tests carried out by the British Cast Iron Research Association showed that irons varying widely in composition did not differ appreciably in their resistance to molten aluminium attack, and consequently the problem resolves itself into one of choosing the composition which will withstand the effects of heating and the stresses imposed at the service temperature. With regard to galvanising pots, zinc attack, which takes place mostly at the molten metal-air line, is materially lessened by regularly removing the dross as it forms. The difficulties of the problem with regard to salt pots are very real, and especially is this the case with molten cyanide pots used for carburising purposes. Much useful information is given by S. Tour.[19, 20]

From a perusal of the literature on the subject one gathers that the material for salt pots must possess the following qualifications: (*a*) It must be capable of being made into castings free from the minutest porosities; (*b*) it must be capable of withstanding the stresses that may be present. These stresses, particularly flange stresses, can be considerably reduced if proper attention is paid to the design of the heating unit; (*c*) it must not grow; (*d*) it must not develop porosities at the working temperatures; (*e*) it must resist molten salt attack, and (*f*) it must not oxidise rapidly.

Salts vary in the rate of attack. Carbonates and nitrates produce rapid corrosion, carbonates being the worst in this respect, as they are used at much higher temperatures than are nitrate baths. Chlorides do not rapidly corrode unless, as is often the case, they contain sulphates as impurities, in which case they have marked corrosive effects. Cyanides are extremely bad, as they have a very searching action and tend to find their way through the minutest porosities, as, for instance, those produced on heating a coarse graphite iron. It is doubtful whether any ferrous material can be really satisfactory for a cyanide pot, but much can be done by correct design of the heating unit to lengthen the life of pots made from relatively cheap materials. Suggestions have been made regarding the possibilities of using double-walled pots, the outer wall being made of a heat-resisting cast iron, the type depending on the conditions existing in the heating unit, and the inner wall of cheap fine-grained iron or mild steel.

BIBLIOGRAPHY.

1 Junker, O.—Water-cooled Moulds: Zeitschrift für Metallkunde, Vol. 18, 1926, p. 312; Metallwirtschaft, Vol. 9, 1930, p. 406.
2 Rohn, W.—Water-cooled Copper Moulds: Zeitschrift für Metallkunde, Vol. 19, December, 1927, p. 473.
3 Morgan, E.—Growth of Cast Irons: Bull. B.C.I.R.A., Vol. 1, No. 20, April, 1928, p. 7.
4 Norbury, A. L., and Morgan, E.—The Effect of Carbon and Silicon on the Growth and Scaling of Grey Cast Iron: J.I.S.I., Vol. 123, 1931, No. 1, p. 413.
5 Norbury, A. L., and Morgan, E.—Nickel-Chromium-Silicon Cast Irons: J.I.S.I., Vol. 126, 1932, No. 2, p. 301.
6 Carpenter, H. C. H.—The Growth of Cast Irons after Repeated Heatings: J.I.S.I., Vol. 83, 1911, No. 1, p. 196.
7 Rugan, H. F., and Carpenter, H. C. H.—The "Growth" of Cast Irons after Repeated Heatings: J.I.S.I., Vol. 80, 1909, No. 2, p. 29.
8 Vanick, J. S., and Merica, P. D.—Corrosion- and Heat-Resisting Nickel-Copper-Chromium Cast Iron: Trans. Amer. Soc. S.T., Vol. 18, July-December, 1930, p. 923.
9 Valenta, E.—Heat- and Acid-Resisting Cast Irons with High Chromium and Carbon Contents: I.S.I., Carnegie Scholarship Memoirs, Vol. 19, 1930, p. 79.
10 MacQuigg, C. E.—High-Chromium Steels for Extreme Service Conditions: American Society for Testing Materials and American Society of Mechanical Engineers, Symposium on Effect of Temperature on the Properties of Metals, June, 1931, p. 432.
11 Pfeil, L. B.—The Constitution of Scale: J.I.S.I., Vol. 123, 1931, No. 1, p. 237.
12 Hatfield, W. H.—Heat-Resisting Steels: J.I.S.I., Vol. 115, 1927, No. 1, p. 483.
13 Kayser, J. F.—Heat-Resisting Metals and their Use in the Ceramic Industry: Foundry Trade Journal, Vol. 47, November 3, 1932, p. 263.
14 Donaldson, J. W.—The Thermal Conductivities of Grey Cast Irons: Proc. Inst. Mech. Eng., 1928, No. 2, p. 953.
15 Bolton, L. W.—Testing Cast Iron at Elevated Temperatures: Bull. B.C.I.R.A., Vol. 3, April, 1933, p. 198.
16 Smalley, O.—Cast Iron and its Chemical Composition: Proc. I.B.F., Vol. 15, 1921-2, p. 688.
17 Donaldson, J. W.—The Strength of Cast Iron at Elevated Temperatures: J. West of Scotland I.S.I., Vol. 38, 1930-31, p. 11.
18 Honegger, E.—Zur Festigkeitsprüfung der Metalle bei hohen Temperaturen (Static Endurance Tests on Cast Iron at High Temperatures): Brown Boveri Cie, Mitteilungen, Vol. 15, November, 1928, p. 315.
19 Tour, S.—Salt Baths: Trans. Amer. Soc. S.T., Vol. 6, August, 1924, p. 171.
20 Tour, S.—Design and Operation of Furnaces for Salt Baths: Trans. Amer. Soc. S.T., Vol. 9, April, 1926, p. 553.

(To be concluded.)

Catalogue Received.

Electric Furnaces.—A 12-page well-illustrated pamphlet, received from the Electric Furnace Company, Limited, 17, Victoria Street, London, S.W.1, served to remind us of the efforts made by the electric-furnace companies of 15 to 20 years ago. This publication carries on its title page "21 Years' Experience of Electric Furnaces," and a small section of a dial labelled "Accuracy with the Pointer Well Centred." In the early days, much was made of the costs of production, but to-day the crystallisation within these few pages of the magnitude of this firm's contribution to general development of the electric-furnace industry is so impressive that one feels that operating costs are available under any and every sort of manufacturing condition. The pamphlet illustrates 27 installations of furnaces of capacities varying from 20 tons down to an odd pound or so—at least so small that it can be lifted bodily and be emptied by hand. We would like to take this opportunity of congratulating the Electric Furnace Company on having given to industry 21 years of successful pioneering service.

American Progress in the Use of Alloys in Cast Iron.

[American Exchange Paper.]

By F. B. Coyle.

(*Concluded from page 22.*)

Heat-Treatment.

Nickel-chromium chilled or white iron is generally used in the "as-cast" condition, but in some applications requiring exceptional resistance to impact or where some slight bending may occur during assembly, it is desirable to submit castings to a heat-treatment. Castings, oil, temper at 204 deg. C., and cool in the furnace or in still air. This is a toughening treatment, and results in, first, a partial solution and breaking up of massive carbides, and, second, after tempering, the precipitation of a portion of these carbides in a fine, uniformly distributed, spheroidised state.

TABLE XI.—*Representative Base Compositions and Ladle Additions which are Successful in Producing High-Strength Cast Iron by the Ladle Graphitisation Process.*

No.	TC	Mn	Si	Ni	Cr	Mo	Ladle Addition Sections ¼" to 2" thick	Ladle Addition Sections 2" to 6" thick
1	2.70-3.00	0.70-0.80	0.75-0.90				1.35 Si + 1.0 Ni or 2.0 Ni	0.85 Si + 1.0 Ni or 2.0 Ni
2	2.70-3.00	0.70-0.80	0.75-0.90	1.00-1.25	0.30-0.40		1.35 Si + 1.0 Ni if desired	0.85 Si + 1.0 Ni if desired
3	2.70-3.00	0.70-0.80	0.75-0.90	2.00-2.25	0.55-0.65		1.35 Si	0.85 Si
4	2.70-3.00	0.70-0.80	1.40-1.60		0.30-0.40		0.75 Si + 1.0 or 2.0 Ni	0.25 Si + 1.0 or 2.0 Ni
5	2.70-3.00	0.70-0.80	2.20-2.30		0.60-0.70		1.0 or 2.0 Ni	1.0 or 2.0 Ni
6	2.70-3.00	0.70-0.80	1.70-1.80		0.30-0.40	0.30-0.40	1.0 or 2.0 Ni	1.0 or 2.0 Ni
7	2.70-3.00	0.70-0.80	2.40-2.60		0.60-0.70	0.30-0.40	1.0 or 2.0 Ni	1.0 or 2.0 Ni
8	2.70-3.00	0.70-0.80	1.10-1.20			0.30-0.40	0.95 Si + 1.0 or 2.0 Ni	0.60 Si + 1.0 or 2.0 Ni
9	2.70-3.00	0.70-0.80	1.40-1.60			0.60-0.70	0.75 Si + 1.0 or 2.0 Ni	0.25 + 1.0 or 2.0 Ni

It is recommended that 0.10 Manganese be added with ladle additions.
80% Ferro silicon is recommended for ladle addition.
Silvery pig containing 8.0% to 15.0% Si or Ferro silicon briquets are recommended for furnace charging.
High carbon 70% ferro-chromium is recommended for ladle addition.
Chromium briquets are recommended for furnace charging.
70% Ferro molybdenum is recommended for ladle or furnace charging.

such as coffee-mill burrs and cereal grinding plates, which must retain maximum hardness, are given the following heat-treatment:—Heat to 900 to 927 deg. C., and hold at that temperature 1 hr. for each inch of thickness, quench in

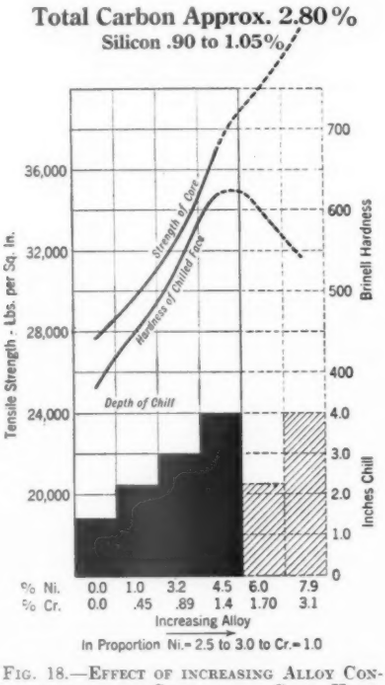


FIG. 18.—EFFECT OF INCREASING ALLOY CONTENT ON THE STRENGTH OF CORE, HARDNESS OF CHILLED FACE AND DEPTH OF CHILL OF CHILLED IRON CASTINGS CONTAINING 2.80 PER CENT. TOTAL CARBON.

Castings, such as roll heads in cement-mill grinders, which must withstand exceptionally severe impact and still resist wear, are usually heat-treated, as follows:—Heat slowly to 870 to 900 deg. C., hold at that temperature 1 hr., and then cool slowly in the furnace. Toughness is obtained by this treatment because of a slight decomposition of carbides with the accompanying precipitation of a small amount of graphite. This toughness is obtained, however, by the loss of about 50 numbers in Brinell hardness.

Physical Properties.

Table XXI shows properties of low- and high-carbon chilled iron with and without nickel chromium additions. The effect of increasing additions of nickel and chromium in the proportion of 2.5 to 3.0 parts of nickel to 1.0 part chromium to iron containing 3.5 per cent. carbon is shown in Fig. 17. Not only are depth of chill and chill hardness increased as total alloy content is increased, but the strength of the grey core is increased considerably. The grey core of the "Ni-Hard" iron (right-hand columns of Table XXI) is about 42.0 per cent. stronger than the core of plain chilled iron of the same base composition. In Fig. 18, the effect of similar alloy additions to a lower carbon iron is shown. The depth of chill is greater and the chill hardness somewhat lower and the strength of the grey core higher than in similar compositions, but of higher carbon content. The proportionate increase in depth of chill, hardness and strength due to added alloy content when nickel is 2.5 to 3 times the chromium is about the same as it is in the higher-carbon irons of otherwise similar compositions.

FIG. 19.—PLAIN CHILLED IRON, SHOWING EDGES OF CEMENTITE AND PEARLITE MUCH SOFTER THAN BODY OF CEMENTITE, AS SHOWN BY SCRATCH TEST (3,000 MAG.).

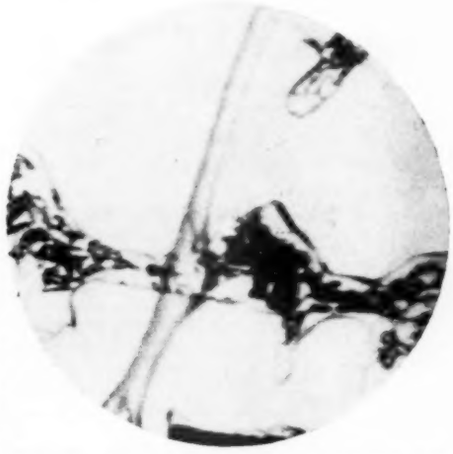


FIG. 20.—ALLOY CHILLED IRON CONTAINING 1.25 PER CENT. MANGANESE, 4.0 PER CENT. NICKEL AND 1.5 PER CENT. CHROMIUM, SHOWING PRACTICALLY IDENTICAL HARDNESS OF CEMENTITE AND MARTENSITE AS SHOWN BY SCRATCH TEST (2,000 MAG.)

TABLE XII.—*Physical and Mechanical Characteristics of High-Strength Cast Iron Produced by the Ladle Graphitisation Process.*

Transverse breaking load	4,500 to 8,000 lbs.
Deflection	0.11 to 0.25 inch
Tensile Strength	50,000 psi (22.3 T. Sq.in.) to 70,000 psi (31.3 T. Sq.in.)
Compressive Strength	165,000 psi (73.75 T. Sq.in.) to 190,000 psi (85.0 T.Sq.in.)
Proportional limit tension	10,000 psi (4.47 T.Sq.in.) to 14,000 psi (6.25 T.Sq.in.)
" " compression	25,000 psi (11.15 T.Sq.in.) to 40,000 psi (17.75 T. Sq.in.)
Elastic Modulus tension & compression	20,000,000 psi to 30,000,000 psi
Brinell hardness	220 to 320
Fatigue Limit	50% to 57% of tensile strength

Resistance to Wear.

Amsler wear-tests have shown that "Ni-Hard" lasts five to twelve times longer than plain chilled iron. Records of cement mill rolls and liners show that while plain chilled iron lasts only 600 to 700 hrs., "Ni-Hard" lasts 4,000 hrs. Coal-pulveriser hammers of plain iron ground

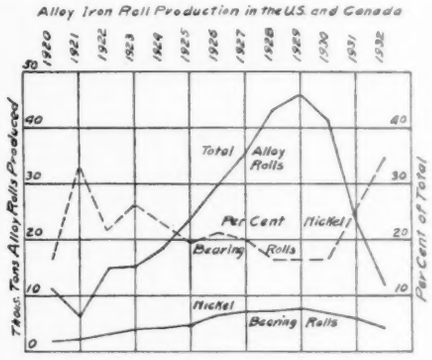

Alloy Iron Roll Production in the U.S. and Canada
1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932
Thous. Tons Alloy Rolls Produced
Per Cent of Total
Total Alloy Rolls
Per Cent Nickel Bearing Rolls
Nickel Bearing Rolls

FIG. 21.—PRODUCTION OF CHILLED AND SAND-CAST ALLOY CAST-IRON ROLLS IN THE UNITED STATES AND CANADA SINCE 1920.

400 to 600 tons of coal, while "Ni-Hard" hammers ground 2,400 to 2,900 tons. Sand-sludge pump bodies and pistons, pumping mine water and sand or concentrates have lasted four to six times as long as manganese steel. The life of a chilled casting depends upon the structure of the matrix of the chill. To obtain maximum resistance to wear, it is necessary that the structure of the matrix be martensitic as found in chilled "Ni-Hard" cast iron.

Machinability.

The low-carbon, high-alloy composition is practically unmachinable behind the chill, particularly if the section be less than 2 in. thick, the grey portion having a hardness of about 400 Brinell. If a low-carbon casting (under 3.0 per cent.) be required having a machinable grey portion, the alloy content must be reduced to about 2.5 to 3.5 per cent. nickel and 0.60 to 0.70 per cent. chromium. Reducing the alloy content may entail some sacrifice of chill hardness, but the latter will still be above that of plain high-carbon iron. Castings of high carbon content (3.30 per cent. and over) are machinable (without reduction in the alloy content) in grey portions of reasonably heavy section (4 in. or over), such sections being free.

Type C is a modification of the standard composition (Type A) in that the range of manganese content is considerably higher. This composition is particularly suitable for chilled rolls. It is unmachinable on the necks and behind the chill and even when cast in sand in sections 10 in. thick. It is very strong and exceptionally tough. The chilled surface will register 80 to 93 scleroscope. It is not only exceptionally hard, but, unlike Type A, the hardness of the martensite is practically the same as the cementite. Fig. 19, a photomicrograph of a scratch hardness test of a plain chilled iron shows a wide scratch through soft pearlite and a narrow scratch through the much harder cementite. Fig. 20, a photomicrograph of a similar test on Type C chilled iron, shows the uniform thickness of scratch throughout both martensite and cementite indicating uniform and equal hardness of both. This ensures equal rate of wear of both and, therefore, longer life between dressings. While high manganese contributes to this effect it is also beneficial through lowering of the critical range. In order to eliminate casting stresses and cracking in the chills, the rolls are usually stripped from the chills when they have cooled to 593 to 649 deg. C. They are then transferred to a furnace held at

TABLE XIII.—*Comparison of Austenitic Alloy and Plain Cast Iron in Contact with Various Corrosive Media.*

Note: Behavior of alloy Austenitic Cast Iron is considered as unity. The figure under plain iron designates how much faster it corrodes than does austenitic alloy cast iron. (a) Aerated (b) Agitated

Corrosive Medium	Austenitic Alloy Cast Iron	Plain Cast Iron
Acetic Acid (25%)	1	400.0
Acetic Acid (38%)	1	49.4
Acetone	1	30.0
Aluminum Sulphate (5%)	1	4.8
Ammonium Chloride (5%)	1	3.5
Ammonium Nitrate	1	3.2
Ammonium Sulphate (10%)	1	3.5
Ammonium Sulphate plus 5% Sulphuric Acid	1	344.0
Atmosphere (1½ years)	1	6.8
Boracic Acid (10%)	1	7.4
Carbon Tetrachloride	1	2.0
Caustic-hot-100 to 300 Tw (b)	1	14.5
Citric Acid	1	160.4
Copper Chloride (10%)	1	1.5
Ferric Chloride (5%)	1	1.5
Ferric Sulphate (b)	1	1.9
Fuel Oil	1	1.0
Formic Acid	1	9.9
Hydrochloric Acid (1%)	1	31.9
Hydrochloric Acid (5%)	1	185.3
Hydrochloric Acid (5%) (a)(b)	1	82.6
Hydrochloric Acid (10%) (a)(b)	1	49.2
Hydrochloric Acid (20%)	1	188.5
Hydrochloric Acid (20%) (a)(b)	1	80.0
Hydrogen Peroxide (20 vols)	1	1.5
Hydrogen Sulphide at 205° F. (96° C.)	1	5.8
Magnesium Chloride (10%)	1	2.4
Magnesium Sulphate (10%)	1	4.5
Molasses (10% solution fermented)	1	36.0
Oxalic Acid (5%)	1	9.0
Phosphoric Acid (50%)	1	179.(
Potassium Alum (10%)	1	24.(
Nitric Acid (1%)	1	1.1
Nitric Acid (5%)	1	1.2
Nitric Acid (20%)	1	1.5
Sea Water	1	2.0
Salt Spray	1	2.0
Sodium Chloride (2%)	1	1.6
Sodium Chloride (5%) (a)(b)	1	2.0
Sodium Chloride-molten at 1500° F. (816° C.)	1	2.2
Sodium Hypochlorite	1	2.1
Sodium Sulphate (5%)	1	0.65
Sodium Sulphite (5%)	1	1.0
Sodium Sulphite (10%)	1	2.0
Sulphuric Acid (1%)	1	62.2
Sulphuric Acid (5%)	1	475.0
Sulphuric Acid (5%) (a)(b)	1	65.9
Sulphuric Acid (5%) plus Hydrogen Peroxide	1	25.4
Sulphuric Acid (10% at 212° F. (100° C.)	1	125.0
Sulphuric Acid (20%)	1	330.0
Sulphuric Acid (70%)	1	1.95
Sulphurous Acid	1	42.9
Tartaric Acid (5%)	1	90.4
Vinegar	1	22.6
Water (Bayonne, N.J.City)(a)(b)	1	2.6

TABLE XIV.—*Austenitic Cast Iron in the Petroleum Industry. Ni-Resist is taken as one. Figures in the other Columns Represent Number of Times that Materials Corrode Faster than Ni-Resist.*

Corrosive Medium	Ni-Resist	Cast Iron	Steel	Wrought Iron	4-5% Cr Steel	18 Cr 8 Ni	15% Cr	60 Ni 10 Cr 30 Fe 35 Cr	12% Cr	Nickel	Monel Metal	Copper	Lead	Tin	Valve Metal	88-12 Bronze	Acid Bronze	Aluminum Bronze	Mitralloy
Acid oil in hot stills - 360°F.	1																30.4		
Naptha Stills (50g H_2S evolution at 320 to 360°F.) Liquid phase -	1	10.0	34.5	17.0	30.5	nil	2.8	nil		6.5	9.3	750.0			326.5	65.3		59.0	
Vapor phase	1	5.3	18.9	5.7	7.7	nil		nil		5.3	4.0	453.3			150.0	85.7		48.0	
Light Naptha plus Acetic water (pb 4-4½)	1	2.4	4.8																
Heavy Naptha plus Sulphuric Acid	1	23.0	46.0																
Sulphuric Acid Sludge - still feed 2.7% H_2SO_4	1	32.5	87.5																
Distillate - Wet Crude Upton Petroleum	1	2.0	1.5									26.0							
Petroleum Vapor	1		20.0									2.5	1.7	1.3			2.5		
Hydrogen Sulphide Saturated Water 160-180°F.	1	3.4	5.0		.04		.02	.35										2.5	

TABLE XV.—*"Ni-Resist" in the Pulp and Paper Industry.*

Corrosive medium.	Std.	Ni-resist. 6 per cent. Cr.	20 per cent. Ni, Cu free.	30 per cent. Ni. Cu free.	C.I.	18–8 S.S.	Bronze.
Hot fumes in burner lines, 950 deg. F.	1	—	—	—	2.8	—	—
Hydrogen sulphide and steam, 200 deg. F.	1	—	—	—	6.2	—	—
14 per cent. SO_2 at 400 deg. F. ..	1	—	—	—	2.0	—	—
Sulphite digester	3.0	1	—	—	2.5	Nil	—
Boiling caustic, 130 deg. T.W. ..	—	—	8.5	1	183.0	—	—
Sulphite stock entering filter. .	3.0	—	—	—	—	—	1
Bleach liquor	1	—	—	—	25.7	—	—

TABLE XVI.—*Rate of Corrosion of Plain Cast Iron, Nickel Cast Iron and Copper-Free "Ni-Resist" in Caustic Evaporators in Test Lasting 54 days.*

No.	T.C.	Si.	Ni.	Cr.	Loss in weight mg. per sq. dec. per day.
1	3.66	0.97	none	none	366
2	3.03	1.11	3.77	,,	235
3	2.88	0.75	6.53	,,	247
4	2.73	0.60	16.66	,,	152
5	2.67	0.65	19.55	1.80	31
6	2.13	0.51	22.24	none	17
7	2.27	0.61	28.90	,,	2

TABLE XVII.—*Comparative Rates of Scale Formation of Various Types of Cast Iron in an Oxidising Atmosphere at 816 deg. C.*

No.	T.C.	Si.	Ni.	Cr.	Original weight. Grams.	Cumulative loss after number of hours at 816 deg. C. Grams. 6	24	72	168	284	Loss due to scaling. Total grams.	Per cent.
1	3.30	1.45	—	—	116.066	6.054	0.068	0.086	24.063	41.414	41.414	35.70
2	3.26	2.02	—	—	115.497	0.016	0.055	9.818	29.368	41.249	41.249	35.75
3	3.22	0.81	2.62	—	116.998	0.045	0.054	0.120	19.002	31.063	31.063	26.60
4	2.60	0.48	13.00	1.48	122.500	0.470	0.877	1.831	9.226	9.735	9.735	8.02

(1) Copper—5.5 per cent.

537 deg. C. and permitted to cool down slowly with the furnace.

These rolls are in use in three-high, four-high and strip mills throughout the United States, where they are rapidly becoming standard equipment for hot- and cold-rolling sheet-steel, tinplate, stainless-steel, copper, brass, aluminium, nickel, zinc and precious metals. One pair of 16 in. by 48 in. working rolls in a four-high mill were surveyed after one year in a hot-finishing stand, rolling 19-gauge sheet steel. The final reduction was 17 to 25 per cent. as compared with 14 per cent. for plain chilled iron rolls. The original diameters of these rolls were 16.500 in.; after having been dressed 47 times they measured 15.995 and 15.985 respectively. The production obtained with plain iron rolls was 150 tons of sheet per grind. The production obtained with these " Ni-Hard " rolls was about 1,500 tons per grind. At the end of the year this pair of rolls had rolled approximately 75,000 tons of sheet at only half their total life, whereas the maximum life of plain iron rolls is 20,000 to 22,000 tons for the entire life of the roll. These are the only rolls used at this mill which have never shown tail-marking.

In Fig. 21 is shown the total production of alloy-bearing sand- and chill-cast rolls manufactured in the United States since 1920. The gain in nickel-bearing roll production in 1930 and 1931 has been due chiefly to the success of Type C composition in this application.

Another type of chilled iron which is used in America for some time for chilled- and white-iron applications contains 1.5 to 3.5 per cent. total carbon, 0.60 to 2.50 per cent. silicon and 14.0 to 30.0 per cent. chromium. However, it has not been possible to obtain much information regarding its manufacture and application. Typical applications of alloy chilled- and white-iron compositions are given in Table XXII.

TABLE XVIII.—*Typical Applications of Plain and Alloy Cast Iron at Elevated Temperatures.*

Application		Temperature range Deg. F.	Deg. C	Total Carbon	Silicon	Nickel	Copper	Chromium	Service
Stoker links (Taylor stoker)	old	1100 max.	593 max.	3.3 3.3	1.75 1.75	1.75		0.70	250 hours 4500 "
Grate bars (Scotch boilers)	old	1100 max.	593 max.	3.4 {3.3 {3.6	1.75 1.60 1.75	1.60		0.50	3 months 11 " (4)
Melting pots for aluminum	old new	1200 max.	646 max.	3.4 3.3	1.70 1.10	2.00		0.70	70 heats 187 "
Valve guides (auto)	old new	1400 max.	760 max.	3.3 3.0	2.0 2.0	14.0	6.0	2.50	Grew and caused seizure Did not grow or seize
Exhaust manifolds (auto)	old new	1100-1400	593-760	3.3 3.2	2.25 1.59	2.00		1.00 (1)	Grew and cracked Did not grow or crack
Liners for hot oil pumps	old new	400-900	204-482	3.0	Bronze 1.75	14.00	6.0	2.0	2 to 5 times longer than bronze
Still tube supports	old new	700-900	371-482	3.5 3.3	2.25 1.35	1.35		0.50	9 months Over 36 months (none failed yet)
Mono Black retorts	old new	1400-1500	760	3.4 3.0	2.00 1.75	14.00	6.0	2.00	9-12 months Over 36 months (none failed yet).
Glass molds	old	900	482	3.4	2.25				(2) 80 hrs. between polishings
	new			{2.8 {3.3	1.60 1.65	1.75 .60			(3) 200 " " " (5)

(1) Annealed at 1400°F.
(2) Chilled
(3) Not Chilled
(4) Contains 0.14 Vanadium
(5) " 0.14 Vanadium; machine readily; take a high polish and do not heat check.

TABLE XIX.—*Carbon and Silicon Ratio required for Various Depths of Chill of " Ni-Hard " Castings.*

Depth clear chill, in in.	½ in.				1 in.				2 in.			
T.C.	2.75	3.0	3.25	3.5	2.75	3.0	3.25	3.5	2.75	3.0	3.25	3.5
Si (max.)	1.95	1.7	1.5	1.4	1.65	1.5	1.3	1.15	1.15	1.0	0.85	0.75

TABLE XX.—*Maximum Silicon Permissible to Obtain White Fracture of " Ni-Hard " when Cast in Sand Moulds.*

Depth chilled white, in in.	½ in.				1 in.				2 in.				3 in.			
T.C.	2.75	3.0	3.25	3.5	2.75	3.0	3.25	3.5	2.75	3.0	3.25	3.5	2.75	3.0	3.25	3.5
Si (max.)	1.25	1.25	1.1	0.9	1.15	1.1	1.0	0.8	0.85	0.8	0.7	0.5	0.65	0.6	0.5	0.3

Conclusion.

The author has attempted to express the progress of the rôle of alloying elements in American founding practice. Graphic charts shown indicate that progress has not only been appreciable, but firmly established. Representative data illustrating industrial applications have been included to demonstrate why the alloying elements have proved valuable, not only in general castings production, but in extending the applicability of iron castings in specialised fields. In many instances previously unpublished data have been included to supplement the illustrative examples in order to clarify the advantages which the alloying elements confer in such cases. It is firmly believed among American foundrymen that the use of alloying elements in iron castings is not only firmly established, but the future will see their use considerably extended.

TABLE XXI.—*Typical Results of Tests of Plain and Nickel Chromium White Irons.*

	Plain Iron		Nickel-Chromium Iron	
	High Carbon	Low Carbon	High Carbon	Low Carbon
Brinell Hardness	500	400	650 to 700	575
Chilled Surface				
Tensile Strength(p.s.i)	(1) 35/40,000	(1) 45/53,000	(2) 55/60,000	(2) 70/80,000
Chilled (T.Sq.in.)	15.63-17.65	22.40-23.68	24.65-26.80	31.15-36.65
Tensile Strength (p.s.i)	16/20,000	22/30,000	30/35,000	40/50,000
Grey Core (T.Sq.in.)	7.15-11.15	9.63-13.40	15.40-18.63	17.85-27.30
Total Carbon	3.80	2.75	3.80	2.75
Silicon	0.75	0.75	0.75	0.75
Nickel	--	--	4.50	4.50
Chromium	--	--	1.50	1.50

(1) Calculated from transverse tests
(2) Test pieces ground to 0.800" diam. gage length from white iron.

Acknowledgment.

The author desires to express sincere gratitude to all who have aided in the compilation of this presentation. Figs. 19 and 20 were furnished by Roy M. Allen. To P. D. Merica, T. H. Wickenden, J. S. Vanick, T. J. Wood and F. E. Kasch, of the International Nickel Company, Incorporated, the writer is particularly indebted for aid in revision of the manuscript and collection of much of the data presented. The collection of much of the data presented was aided by the efforts of A. C. Meyers, C. R. McGrail, C. E. Brinker, W. J. Brown and D. M. Avey. To H. Bornstein is expressed thanks for reviewing the manuscript. Considerable aid in collecting and arranging data was afforded by the hearty co-operation of:—The Climax Molybdenum Company; the Molydenum Corporation of America; the Vanadium Corporation of America; the Electro Metallurgical Company; the Pittsburgh Rolls Corporation; Continental Steel & Roll Foundry; United Engineering Company; Duquesne Steel Foundries; Youngstown Foundry & Machine Company; National Roll Foundry; and Jewell Steel & Malleable Company.

TABLE XXII.—*Representative Compositions of Alloy Chilled and White Iron.*

Application	Total Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium
Ash pan liner plates	2.75-3.25	0.4-0.5	0.05-0.10	0.13-0.16	1.35-1.60	2.75-3.25	0.85-1.00
Cams (heavy)	3.10-3.30	0.5-0.6	under .30	under .12	1.10-1.20	2.75-3.25	0.50-0.60
Crusher jaws	1.50-2.50	--	--	--	0.60-1.50	--	22.00-30.00
Dies (clay brick)	3.10-3.30	0.4-0.5	" .20	" .12	1.40-1.60	4.75-5.25	0.45-0.55
Incinerator parts	1.50-2.50	--	--	--	1.00-2.50	--	14.00-30.00
Liners (rod mill)	3.20-3.40	0.4-0.5	under .30	under .12	0.90-1.00	4.25-4.75	1.45-1.55
" (grinding mill)	2.50-3.50	--	--	--	0.70-0.80	--	2.00-3.50
Pots (die casting)	3.10-3.30	0.4-0.5	under .20	under .12	0.80-1.00	4.00-5.00	1.50-2.00
Pump plungers	3.40-3.60	0.4-0.5	" .20	" .12	0.60-0.70	5.00-6.00	2.50-3.00
Races (roller bearing)	3.15-3.25	0.7-0.9	" .20	" .10	1.15-1.25	3.75-4.25	1.10-1.30
Rolls - chilled (cold sheet finishing)	3.40-3.60	0.35-0.45	" .20	0.2-0.3	0.80-1.00	2.25-2.50	0.70-0.80
(" " ")	3.40-3.60	1.25-1.50	" .20	under .12	0.80-1.00	4.00-4.50	1.40-1.60
(cold breaking down)	3.40-3.60	0.35-0.45	" .20	under .10	0.90-1.00	4.25-4.75	1.40-1.60
Briquetting	3.20-3.40	0.40-0.50	" .20	" .12	0.80-1.00	2.00-3.50	0.80-1.50
Cement Mill	3.40-3.60	0.40-0.50	" .20	" .12	1.70-1.80	4.75-5.25	1.50-2.00
Pipe	2.90-3.10	0.40-0.50	" .20	" .12	0.80-1.00	2.75-3.25	0.70-0.80
Rust free (hot finishing)	1.50-2.50	--	--	--	0.60-1.25	--	22.00-30.00
Sand Pump Casings	3.10-3.30	0.30-0.40	under .20	under .12	0.50-1.00	4.00-4.50	1.40-1.60
" " Plungers	3.00-3.20	0.70-0.90	" .20	" .12	0.60-0.70	4.25-4.75	1.90-2.10
" " Impellers	3.10-3.30	0.30-0.40	" .20	" .12	0.50-1.00	4.00-4.50	1.40-1.60

Sand Testing in the Foundry.

Mr. Wm. G. Buchanan, the well-known expert on sand testing for foundry use, was chosen to present a Paper on that subject to the Polish Foundrymen's Association on behalf of the Institute of British Foundrymen. With the exception of the following matter, the material he presented has previously appeared in our columns.

As the interchange of views on technical subjects is becoming more prevalent between countries, the question of international standards is always one of the utmost interest, and in the study of sands this is undoubtedly so because in most countries this branch of foundry technique is at the stage of rapid development. The fact that many workers have from time to time been actively engaged in the study of the subject testifies to the real desire for improvement in the method of expressing the well-known properties of sand which, to a great extent, form the foundation of the art of moulding. Real international co-operation in the study of sands, as in any other branch of science, must be preceded by international standardisation of methods, and these methods must be founded on test-pieces which are sound in principle and convenient to make and use.

In Britain there are available the methods of two technical institutions; those of the American Foundrymen's Association which have been in use in America and elsewhere for a number of years, and those of the British Cast Iron Research Association which are of more recent origin. The methods of these two technical bodies for measuring the green strength and permeability of moulding sands are quite different, and those engaged in the industry are obliged to choose between them.

Density Determination.

The determination of the true density of sand by the use of the usual size of density bottle, of 50 c.c. capacity, was found to be very unsatisfactory, due to the presence of air in the sand, etc. The following method is suggested for foundry work. The flask is of 1 litre capacity and has a wide neck, into which fits a small-bore tube having a mark on the stem. The water used should be distilled water which has been allowed to attain room temperature. This size of density bottle allows a sample of 700 or 800 gms. to be used, and the weighing can be done on a large balance to the nearest gramme.

If a moisture determination be carried out at the same time, the sample need not be dried, for the estimation of density for the weight of dry sand can be got by a simple correction, and there is less trouble with air froth when a moist sand is used. About half of the distilled water should be added, and the vessel gently tapped or jarred to assist the escape of air, and after filling up to the neck the froth can be removed by adding a few drops of methylated ether or other liquid with the same effect. The excess of ether can be removed by a gentle blast of air.

The small-bore tube should then be replaced after carefully cleaning the ground glass joint and applying a little petroleum jelly. The vessel is now filled up to the mark with water and the level adjusted to the mark by inserting small pieces of absorbent paper down the tube as required. The density is, of course, obtained by dividing the weight of dry sand by the weight of the same volume of water.

Furthermore, as the relative merits of these methods is a matter of considerable interest, much discussion and research work has been carried out on the test methods, and many modifications have been tried out with the object of combining the good points of both.

Green Strength and Permeability.

In the comparison of these methods, the first consideration is the size and shape of the test-pieces. The A.F.A. test-piece is 2 in. dia. and 2 in. high, while the B.C.I.R.A. test-pieces are 1.128 in. dia. and 2.268 in. long, and 7.14 cm. dia. and 20 cm. long for green strength and permeability respectively.

The second consideration is the method of ramming. The author has found "hand ramming" to be liable to give erratic results in the case of the 1.128-in. dia. B.C.I.R.A. test-piece, although quite good results were obtained on the 7.14-cm. dia. test-piece used for permeability. The B.C.I.R.A. method is the "ram the test-piece evenly," and if this has been done, the ideal test-piece has been made. The A.F.A. standard ramming method, *i.e.*, three blows on the top end by a standard weight of 14 lbs. falling 2 in., does not necessarily give this ideal condition, while the methods of making the test-piece by controlled double compression give uniform ramming under a variety of sand conditions.

The third consideration is the method of testing. Any inequality in the degree of ramming

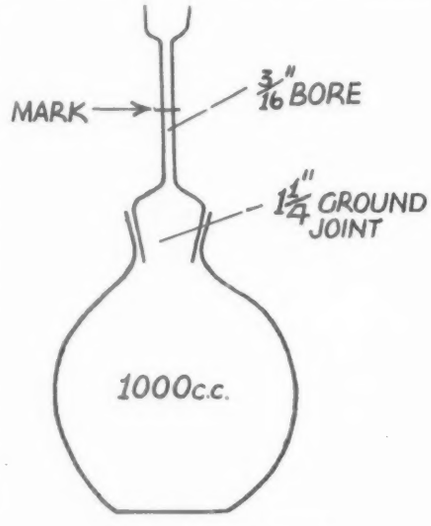


FIG. 1.—DENSITY BOTTLE.

may cause an error in the results of both strength and permeability. The B.C.I.R.A. method consists of passing coal gas through the test-piece and noting the time which elapses before this ignites at the top of the core.

With reference to modification of the permeability test, one method consists of passing air through the test-piece and noting the back pressure resulting from a fixed head of water. This was intended to eliminate the time measurement, and the permeability is reported as inches of water. A later modification, by the B.C.I.R.A., is a simple bell or gasometer loaded so as to displace air at a constant pressure through the test-piece. This principle has been used by many of the earlier workers on sands and is used in the testing of cements, etc. It is also the principle of the standard A.F.A. method.

The advantages of the B.C.I.R.A. testing methods over the A.F.A. methods are the ability to test at various densities at will. The possible methods of ramming the test-piece are hand ramming, squeezing and standard ramming by a falling weight.

Corrosion Resistance of Fe-Cr-C Alloys.—In the "Techn. Mitt. Krupp," C. KÖTTNER suggests that corrosion resistance in alloys is due to the presence of passive surface layers. Experiments with a number of Fe-Cr-C alloys containing up to 3 per cent. C and 70 per cent. Cr show that in accordance with the Tammann theory of reaction limits corrosion resistance suddenly increases at n/8 mols. of Cr in these alloys.

New Super Refractory.

(*Concluded from page* 18.)

When comparing the results obtained with different classes of refractories it is not sufficient to consider the life alone. It is essential to take full account of other advantages which can be obtained, such as reduced hearth repairs. The use of Siemensite in suitable positions leads to a decrease in the time occupied by fettling and consequently an increase in available melting time. Marked economies are therefore effected due to reduced heat losses and increased output.

The following example shows that a figure for the consumption of refractories alone is often misleading.

Until furnace No. 3 was shut down (July 13, 1932) the consumption of refractories was 42 lbs. per ton of steel with a production of 73,200 tons of steel. This consumption, however, includes the total requirements of refractories for the rebuild from the chequer-chamber base, as well as for all repairs on furnaces and flues. These 42 lbs. consist of 23 lbs. per ton of steel for the rebuilding of the furnace and 19.5 lbs. for repairs.

From the total consumption of 42 lbs. must be deducted: For Siemensite, 3.8 lbs. per ton; for magnesite, 3.0 lbs. per ton (bottom).

For furnace No. 1, whose reconstruction from regenerator-floor level was carried out at a much earlier date, the total consumption of refractories is 30 lbs. per ton of steel with a production of 70.173 tons. From this must be deducted 1.1 lbs. of magnesite and 2 lbs. of Siemensite per ton. The consumption of refractories is higher on a furnace shortly to be taken off for rebuilding (even during the melting time) than on a furnace in first-class condition. Figures of consumption of refractories should contain all usages, without exception, both for the upper and lower part of the furnace, including flues. Such figures have only a value of comparison if they represent the true average over years.

As previously mentioned, the most recent results at Brandenburg show a further decrease in the refractory consumption which is now 26½ lbs. per ton of steel, made up as follows:—0.6 lb. of magnesite; 1.28 lbs. of Siemensite; 24.58 lbs. of silica and firebricks; total 26.46 lbs.

Under the conditions at Brandenburg, the cost for this material is only 0.92 Rm. per ton or 1s. 3d. at the present rate of exchange. This figure includes all refractories for rebuilding the furnace and repairing the gas producers and the flues. This refractory consumption is confirmed by the high melting capacity (including all stoppages, holidays and heating-up times) of the furnaces at Brandenburg, because such melting capacities can only be obtained if the furnaces require no repairs worth mentioning during their lifetime.

It may be added that the backwalls in Siemensite and the bridge banks require no repairing with dolomite during the whole furnace campaign. Only the edge of the hearth at the slag line requires a little fettling after each charge. The result is that the time spent in repairing the dolomite hearth is only 1.5 per cent. of the whole working time compared with 4 per cent. to 6 per cent. in average British practice.

Pig-Iron and Steel Output.

The National Federation of Iron and Steel Manufacturers states that there were 72 furnaces in blast at the end of June, the same number as at the beginning of the month. The production of pig-iron in June amounted to 345,600 tons compared with 339,900 tons in May and 311,400 tons in June, 1932. The production included 87,800 tons of hematite, 158,600 tons of basic, 82,800 tons of foundry and 6,700 tons of forge pig-iron. The output of steel ingots and castings in June amounted to 568,800 tons, compared with 599,600 tons in May and 459,300 tons in June, 1932.

Company Meeting.

Buell Combustion Company, Limited.

ERECTION OF TRIAL PLANTS—POTENTIALITIES OF THE SYSTEM.

The sixth ordinary general meeting of the Buell Combustion Company, Limited, was held on July 14 at the Hall of the Institute of Chartered Accountants, London, E.C.

MR. JOHN A. AGNEW (the chairman), after dealing fully with the accounts, which showed a small profit on the year's working, explained what had led up to the change in the personnel of the board and its resumption of control of its own business, so far as its development on the land side was concerned. He said :—

Several months ago New Consolidated Gold Fields, Limited, was approached and asked if it would be possible to secure the co-operation of the mechanical department of that company in the development of your company's business. After going very carefully into the position of the Buell Company, and after making a thorough study of the company's progress, Gold Fields decided that the prospects of the latter appeared to warrant their becoming interested therein, with the result that the offices of the Buell Company were removed to those of New Consolidated Gold Fields, Limited, a representative of the latter being appointed to the board, and arrangements were made whereby the technical staff of the Buell Company were afforded the complete co-operation of the mechanical department of Gold Fields.

The Buell Company in the meantime had arranged with Messrs. Samuel Hodge & Sons for the latter, while carrying on representation so far as the marine side of the company's business is concerned, to relinquish that portion of it dealing with the land installations, which the company decided to retain in its own hands.

Vigorous Development Campaign.

Following the steps I have just outlined, a careful scrutiny of the position made perfectly clear the necessity of a vigorous campaign in the direction of demonstrating to steam users the importance and utility of the company's processes if anything approaching a successful result was to be achieved. The technical staff of the company was strengthened, and in the United Kingdom certain engineering firms, carefully selected, were appointed as agents to whom inquiries could be directed, and a system of establishing demonstration units was adopted by means of which potential users of our products could be made better acquainted with the value of the latter.

Incidentally, I ought to mention that this work has been carried on during the last few months at a time when those industries which could be expected to interest themselves in the Buell Combustion system were, from point of view of trade, at a very low ebb. It was felt, however, that when the improvement in business which was regarded as inevitable did occur there would be a vast amount of reconstruction work undertaken in the case of a great many plants, and it was necessary therefore for us to be prepared to take advantage of such improvement, in the confident belief that, by convincing the controllers of certain industries of the efficiency that would be effected and the economies which could be made by the adoption of our process, we should find the volume of business which would ensue amply justify us for the risks taken. We are having to contend with the inertia caused by there having been, for no doubt a good reason, very little effort made in the last few years to develop the land side of the company's business, and the conservatism of a great many controllers of steam-using plants is another factor which militates against any rapid development. If to these is added the fact I have already stressed, that industry generally in the last few months has not been in a very flourishing state, our difficulties may be readily appreciated.

Endeavours to Attract Clients.

I have already referred to the fact that we are doing our utmost to create the right kind of interest in our products by the establishment of demonstration plants in various centres. In addition to this, we are endeavouring to encourage the owners of large steam plants to look more closely into what we have to offer by undertaking to refit one section of their plant with our own particular system at cost, or very little above it, on the understanding that if our guarantees as to efficiency and economy are established further extensions of the system will follow. In this way it is hoped gradually to extend our business, and it is perhaps unnecessary to point out that the successful operation of the Buell system in even one large plant in this country would attract a great deal of attention from other potential clients.

It is not only in connection with steam-raising plants that our pulverised-coal-firing equipment is in use; we are at present installing equipment on malleable-iron annealing furnaces at the works of one of the principal ironfounders in the Midlands, which to-day is a very important centre of activity. We are endeavouring also to have this equipment installed in connection with various metallurgical processes, with, I may safely say, every promise of success.

Extensive Field for the System.

A very important field for the system exists in connection with locomotive firing, and a scheme has been developed for application to a standard type of locomotive; this is at present under the consideration of a well-known firm in this country. We are hopeful, from the discussions that have taken place, that we shall eventually develop quite a lucrative field in the direction indicated.

A further development has been the design of a modified form of the system for small sectional heating boilers, application of which was not possible previously owing to the fact that the equipment could not be economically applied to such small units. There should be a very wide scope in this field, as many of the sectional heating installations are now oil fired.

Recent reports from our marine licensees, Messrs. Samuel Hodge & Sons, Limited, indicate that the pulverised-coal plants on the T.S.S. "Hororata," of the New Zealand Shipping Company, and the S.S. "Gogra," of the British India Steam Navigation Company, continue to operate satisfactorily.

Our system has recently been applied to two large tugs belonging to the Rhine Steam Navigation Company, by the Etablissements Jean Aube, who are representing our interests in France and Belgium. It is important to note that these installations have replaced plants which were put in by competitors, and we are informed that they are giving entire satisfaction.

Development Overseas.

It became apparent not long ago, from the many inquiries received from India, that representation in that country was necessary, and we have recently appointed a consulting engineer who has had experience of conditions in India and who is fully conversant with our system of firing, and he will devote his whole time to the furtherance of our interests. Our system has already replaced that of a competitor at Delhi, and complete pulverised-coal-firing equipment with raw coal intake and conveying plant has recently been supplied for installation in Calcutta. These plants will be of considerable assistance in the demonstration of our equipment.

We have already pulverised-coal-firing equipment installed in connection with lead-dross furnaces in Burma, and these, we are advised, are operating very efficiently.

It is felt that there are possibilities for developing our firing system in South Africa, and negotiations are at present in hand for the equipment of a boiler for the purpose of indicating to steam users in that country the efficiency of the system. In this connection we are fortunate in having the assistance of the engineering staff in South Africa of the New Consolidated Gold Fields, Limited.

The Pulvex Mill.

Appreciating that the most important component of a pulverised-coal installation is the pulverising mill, the necessity of developing on our own account a mill much more suitable to our own requirements than those at present in use has become more and more apparent, and we have acquired the world rights, exclusive of France and Belgium, of the Pulvex mill, which, after thorough investigation and the carrying out of stringent tests, has been proved to possess decided advantages over existing types of mill. Arrangements are being made in this country for the manufacture of this machine in various sizes to meet industrial requirements. Special features of design of the Pulvex mill will enable it to be manufactured and marketed on very favourable terms to meet varying requirements of industry.

It is essential that we should not be limited to one type of pulveriser, and we are therefore interesting ourselves in an entirely new machine which is now in course of manufacture, and will be submitted to rigid tests in the course of the next three weeks. It will be appreciated that our interest in these two pulverisers places us in a very strong position in regard to this phase of our work.

We have recently acquired on very favourable terms the Davidson grate for use in conjunction with our feeding and burning equipment for firing non-marketable fine coals for steam-raising purposes, large quantities of these fines being available at collieries throughout the country. It is proposed to advocate the use of these grates where certain collieries are not disposed to spend money on pulverising equipment, and the adoption of this system of burning fine coals in suspension should have a great appeal to colliery owners by reason of reduced capital outlay and operating costs. Many important inquiries have been received from colliery owners, and these are receiving attention.

Buttner Dryers.

In conjunction with Messrs. Edgar Allen & Company, Limited, of Sheffield, we are on the point of concluding arrangements with the object of obtaining the sole licence for the manufacture and sale of Buttner dryers for the British Empire. This is an important development, since it not only enables our company to offer its own drying plant in conjunction with pulverised-coal-firing installations, but extends the whole field of our activities. Competent authorities place the Buttner Drying System far in advance of any other system of drying, and it has been in commercial application for nearly half a century. Many important installations have been effected in this country, and there are excellent prospects of substantial business maturing in the course of the next few months. These dryers are applicable to many industries apart from coal, and to deal with this side of the business we are considering setting up an organisation which will also handle our pulverisers for general trade grinding purposes. In the past we have experienced very considerable disadvantage through lack of manufacturing facilities, and, by reason of our association with Messrs. Edgar Allen and Company, it is expected that these disadvantages will be overcome.

I make no apology for endeavouring to thus put before you a complete statement—first of all, of the difficulties that we have had to contend with, and, secondly, the means by which we hope to overcome these and to place the company on a sound commercial footing.

It will be obvious to shareholders that even with normal trade conditions some difficulty would be experienced in creating interest in a process which, for one reason or another, has not been actively developed for some considerable time past. This difficulty is vastly increased when it is borne in mind that in almost every direction there has been a disinclination to make capital expenditures in the depressed state of industry. This, however, has not deterred us from making a very earnest effort to bring to the notice of potential users, in a manner calculated to cause them little risk, the advantages not only of our system of firing, but of the other adjuncts to which I have referred, in the hope that once the real efficiency and economy is appreciated, our material will speak for itself, and the company benefit from the revival of trade, which now appears to have commenced.

Since the date of the last meeting, Mr. J. W. Murray, the late chairman, has found it necessary, on account of pressure of other business, to retire from the board. The present directors desire to place on record their appreciation of the services rendered to the company by Mr. Murray under exceedingly difficult conditions. During the recent reorganisation of the board, Mr. Murray was pressed to remain on the board, but he found it impossible to do so.

Services of Dr. Blythe.

In concluding my remarks, I should like to refer to the excellent service being rendered to the company by its technical adviser, Dr. G. E. K. Blythe. Dr. Blythe is most assiduous in doing everything possible to further the interests of the company, and, what is very much to the point, he is thoroughly imbued with the desire to conduct negotiations with potential clients along lines best calculated to create a feeling of complete confidence in our being able to carry out all that is undertaken. This is important when it is realised that in many cases we offer guarantees of efficiency and economy, expecting by the due fulfilment of such to establish and maintain connections that ought to be for our lasting good.

MR. H. C. HOLDER seconded the resolution, which, in the absence of question or comment, was carried unanimously, and the formal business was transacted.

This Week's News in Brief.

Trade Talk.

MR. G. H. NELSON has been appointed chairman of the English Electric Company, Limited. He retains his position of managing director.

THE CENTRAL IRONWORKS, Huddersfield, of Messrs. Thomas Broadbent & Sons, Limited, engineers, were closed down on Friday, July 14, until 9 a.m. on Monday, July 24, for the annual holidays.

IT IS INTERESTING to record that both the Junior and Senior T.T. races have been won by machines in which Bradley's refined cylinder iron has been used for the cylinder castings. Bradley's iron was again used in a large majority of the machines competing.

THE NEW DREDGER "Foremost Prince," built by the Blythswood Shipbuilding Company, Limited, Scotstoun, Glasgow, for the James Dredging, Towage & Transport Company, Limited, Southampton, has completed successful trials, and left the Clyde for Southampton to take up service.

AT THE HAMILTON DEAN OF GUILD COURT last week the Lanarkshire Bolt & Rivet Company, Limited, Burnbank, were granted permission to erect an extension to the works. The plans showed a building 160 ft. long by 40 ft. wide, constructed of steel and iron, to be used as additional workshop accommodation.

MESSRS. BRUCE, PEEBLES & COMPANY, LIMITED, Edinburgh, have appointed Messrs. Ritchie, Hart & Company, Limited, of Mountpottinger Foundry, Belfast, as agents for the sale in Northern Ireland of Bruce Peebles rotating electrical machinery, static transformers, steel-cylinder and glass-bulb mercury-arc rectifiers and rectigors.

THE ENGLISH ELECTRIC COMPANY, LIMITED, and the Metropolitan-Vickers Electrical Company, Limited, have been awarded an important contract, amounting to about £2,000,000, by the Polish Government, for the electrification and completion of the main Warsaw Railway junction. The two firms will supply part of the equipment.

THE NORTH EASTERN MARINE ENGINEERING COMPANY, LIMITED, Wallsend, have booked contracts for converting to superheating the "Nyanza," belonging to Messrs. Maclay & McIntyre, Limited, Glasgow, and the "Nagara," owned by Royal Mail Lines, Limited, which will make six vessels in hand by the firm for these machinery improvements.

MESSRS. HARGREAVES BROS. have commenced business as suppliers of foundry equipment, facings and general requisites at Wheathill, Salford, 3. Their telephone number is Blackfriars 9510. The partners had a long and extensive experience with Messrs. Grandidge & Mansergh, Limited, before that company decided to enter into voluntary liquidation.

FOR THE FIRST SIX MONTHS of this year the orders secured by the English Steel Corporation, Limited, have been £271,000 more than those obtained during the first half of 1932. This was disclosed at the employees' gala at Sheffield recently by Commander C. W. Craven, managing director. He added that he thought the general feeling that things in the country were improving was justified.

MESSRS. RILEY, HARBORD & LAW, consulting metallurgists and chemists, state that, owing to the termination of the lease of their laboratories, they have decided to combine their offices, chemical laboratories and cement- and concrete-testing laboratories in one building, and have therefore taken premises in Parliament Mansions, Orchard Street, Victoria Street, London, S.W.1, to which address all communications should now be sent.

SEPARATE EXTRAORDINARY GENERAL MEETINGS of the holders of the 5 per cent. "A" mortgage debenture stock and the 4½ per cent. mortgage debenture stock of the Fairfield Shipbuilding & Engineering Company, Limited, were held on July 18, for the purpose of passing special resolutions authorising the trustees of these stocks to concur with the directors of the company in obtaining an advance of £150,000 which has been provisionally arranged to meet the present financial position of the company. The resolutions were passed and they will be submitted for confirmation at further separate extraordinary general meetings, which will be held on August 2.

IT WAS EXPECTED that the annual trade holidays in Motherwell would be of longer duration than usual this year, but in several of the works in the district a surprising briskness has developed, and the holiday period has been curtailed. At an engineering works where special machinery is manufactured, and where a night shift has been in operation for some time, a restart was made on July 19. In one of the steelworks where notices had been posted intimating a restart on July 25, a new notice was posted on July 13 intimating that the restart would take place on July 17. The majority of the works will restart on July 24 or 25.

AT THE ANNUAL MEETING of the American Foundrymen's Association, the following officers and directors were declared elected:—President, Mr. Frank J. Lanahan, Fort Pitt Malleable Iron Company, Pittsburgh; Vice-President, Mr. Dan M. Avey, Penton, Publishing Company, Cleveland; directors, Mr. George Batty, Steel Castings Development Bureau, Narberth, Pa.; Mr. T. S. Hammond, Whiting Corporation, Harvey, Ill.; Mr. R. F. Harrington, Hunt-Spiller Manufacturing Corporation, Boston, Mass.; Dr. H. Ries, Cornell University, Ithica, N.Y.; Mr. R. J. Teetor, Cadillac Malleable Iron Company, Cadillac, Mich.; Mr. J. L. Wick, jun., Falcon Bronze Company, Youngstown, Ohio.

THE SUMMER MEETING of the Institution of Mining Engineers, which opened on July 12, was held for the first time in 25 years in Edinburgh. Sir Thomas Holland, Principal and Vice-Chancellor of the University, who was the first President of the Institution, in extending a welcome to the members, said that they had come to a district which must always remain in the minds of the students of geology, a place recognised as classical ground. Although science was not in earlier days a strong line in the University of Edinburgh, since 1868 they had had six principals, four of whom had been Presidents of the British Association. Geology was not recognised as a science worthy of a separate professorship until 1870, and engineering became a separate chair in 1868. Since then they had developed in the direction of applied science, and nine years ago, through the generosity of one of the members of that Institution, Dr. James Hood, a chair of mining was endowed. The Principal said he had the privilege of welcoming the members as Principal and Vice-Chancellor of the University and as one of their members of 23 years' standing with real cordiality.

Contracts Open.

Cairo, August 15.—Pumping set, for the Egyptian Ministry to the Interior. The Department of Overseas Trade. (Reference G.Y. 12,745.)

Bedford, July 24.—Oil-cooled, three-phase and one-phase transformers, for the Town Council. The Borough Electrical Engineer, Prebend Street, Bedford.

South Africa, September 11.—Two steam tugs, for the South African Railways and Harbours Board. The Department of Overseas Trade. (Reference A.Y. 11,866.)

Istanbul, August 16.—150 tons of iron telegraph wire, for the Turkish Department of Posts, Telegraphs and Telephones. The Department of Overseas Trade. (Reference G.Y. 12,748.)

London, S.W.—400 tons of c.i. segments for London County Council pattern sewer, ext. dia. 6 ft. 4 in. Messrs. D. G. Somerville & Company, Limited, 36, Grosvenor Place, S.W.1.

Midhurst, July 22.—Supply and laying of 3,000 yds. of 6-in. and 4-in. cast-iron mains, with valves, etc., for the Midhurst Rural District Council. Messrs. J. Taylor & Sons, Caxton House, Westminster, S.W.1. (Fee £5, returnable.)

New Companies.

Frank Butler, Limited, 12a, Church Lane, Stepney, E.1.—Capital £1,000. Engineers, founders, etc. Directors: F. Butler and C. Butler.

Metal Sprayers, Limited, 34-6, Gresham Street, E.C.2.—Capital £1,000. Metal sprayers, oxidisers, etc. Directors: Major C. B. White, C. Fairbrother and H. T. C. Culliford.

Company Report.

Hammond Lane Foundry Company, Limited.—Interim dividend of 5 per cent. on the ordinary shares.

Personal.

MR. E. MORTON, late foundry manager of the Suffolk Iron Foundry, has started business on his own account at Prentice Road, Stowmarket, as an iron and brass founder.

MR. ALFRED CHESTER BEATTY, who is a director of the American Metal Company and a member of the American Chamber of Commerce in London, has decided to apply for naturalisation in England.

MR. AND MRS. ROBERT SCOTT, of Millerston, Glasgow, have celebrated their diamond wedding. Until he retired a few years ago, Mr. Scott was employed for over 40 years with the Gartcraig Fireclay Company, Limited.

AT THE CLOSING of the Brickworks Department of the Morningside Fireclay Company, Limited, Motherwell, on July 11 for the annual Fair holidays, the works staff met to honour the works manager, Mr. Robert Currans, on the occasion of his approaching marriage. Mr. Robert Falloon conveyed the esteem and goodwill of the works staff and their sincere and best wishes for his future happiness, and asked his acceptance of a dinner set and a Japanese vase. Thereafter the toast of the "Bridegroom" was enthusiastically pledged and acknowledged by Mr. Currans.

MR. ALBERT C. JENKINS, of Bede Burn Road, Jarrow, manager of Palmer's Shipbuilding & Iron Company, Limited, of Hebburn, has retired with a record of 44 years' service. A Welshman, Mr. Jenkins has had 52 years' experience in shipbuilding and ship-repairing work. He arrived on Tyneside in 1889, and was with Messrs. Swan & Hunters, of Wallsend, before going to Messrs. Palmers, where he specialised for some time in repair work, being mainly responsible for the reconditioning of H.M.S. "Lion," Lord Beatty's famous flagship, after the Battle of Jutland, carried out in a specially-constructed cofferdam. The work was regarded as one of the finest examples of British skill and craftsmanship in record time.

Obituary.

SIR JOHN ELLERMAN, the shipowner, who had extensive industrial interests, died at Dieppe on Monday.

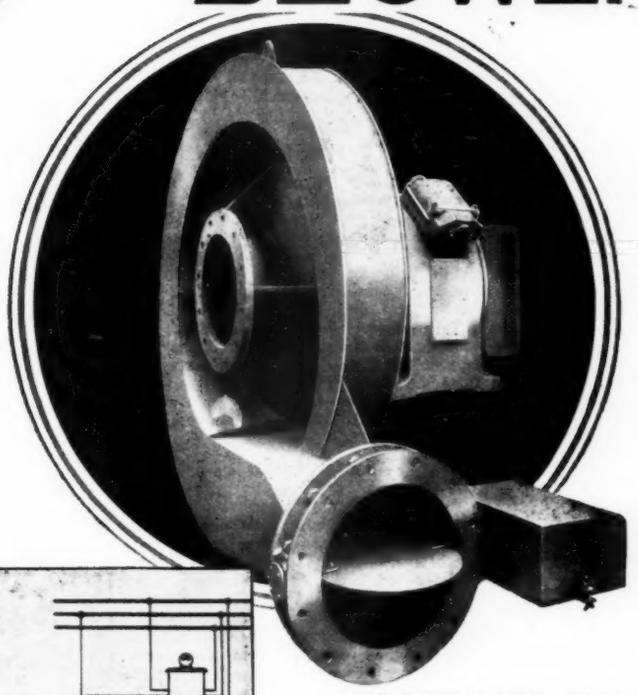
THE DEATH OCCURRED at his home in Paisley on July 11 of Mr. Hugh Davie, in his 72nd year. Mr. Davie was for many years with Messrs. A. F. Craig & Company, Limited, Caledonia Engine Works, Paisley.

THE DEATH OCCURRED very suddenly on July 12 of Mr. Alexander M'Gregor, general works manager of the Coltness Iron Company, Limited, Newmains, Lanarkshire. Mr. M'Gregor, who was in his 70th year, was on holiday with his family at Llandudno, having left a week previously in apparently good health. He had a sudden heart seizure, and passed away almost at once. Mr. M'Gregor was a native of Newmains, having served an apprenticeship in the engineering and pattern-making departments of the Coltness works. Forty years ago he was appointed superintendent of the engineering works of the company, and had charge of all the recent erections at the works, including extensions to the blast-furnace plant, by-products plant and cement works. About ten years ago he was appointed general works manager.

MR. VALENTINE BEARDMORE STEWART, a former director of Messrs. William Beardmore & Company, Limited, Glasgow, died suddenly in London on July 13. Mr. Stewart was for many years works manager of Parkhead Forge. He was 51 years of age and well known in iron, steel and engineering circles in the West of Scotland. Mr. Stewart served his apprenticeship as an engineer in his father's works, now known as Duncan Stewart & Company, Limited, London Road Ironworks, Glasgow. He then went to Parkhead Forge as works manager in 1911. He took up military service at the outbreak of war, was invalided after two years' service in Gallipoli, and appointed Controller of Gun Manufacture under the Minister of Munitions. He received the O.B.E. in 1918, and two years later was made C.B.E. On re-entering private industry after the war, he carried out administrative duties in connection with the Beardmore reorganisation and became a director, a position he held until 1929. Mr. Stewart took a prominent part in the proceedings of the annual meeting of shareholders in Messrs. William Beardmore & Company, Limited, the day before his death.

XUM

B T-H CUPOLA BLOWERS



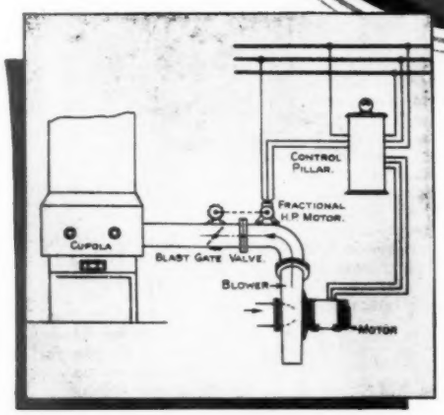


Diagram showing arrangement of Cupola Blower, Motor and Control Equipment.

CONSTANT AIR WEIGHT

The control panel automatically operates the blast-gate valve so that a constant weight of air is delivered to the cupola irrespective of atmospheric conditions, or resistance through the cupola.

The results are :—

Improved efficiency of the melting operation.

Higher grade castings.

Low coke consumption.

Less wear and tear of the cupola.

Reduced power consumption.

WRITE FOR FULL PARTICULARS

BTH RUGBY

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, RUGBY, ENGLAND A 1424

Raw Material Markets.

The iron and steel markets maintain their steady tone, and business is upheld very well in view of the time of the year. Some slackening off must be expected as August approaches. The rate at which deliveries of pig-iron are going into consuming works is well maintained on the whole, although there is not a great deal of new business about. Activity at the steel mills shows little change one way or the other, but there is a lull in business, the markets having been disturbed by renewed offers of Continental material at prices which are below the official rates fixed by the European Steel Cartel. Steady conditions rule in the scrap markets, and prices are maintained.

Pig-Iron.

MIDDLESBROUGH.—There is less activity in the Cleveland pig-iron market, but the demand is sufficient to absorb the output of the furnaces and a firm tone is maintained. The holidays in Scotland affect this market, and inquiry from other areas is also less active. The makers, however, still have a fair number of orders on their books, and, considering the period of the year, are not in a bad position, although, of course, there is still much idle plant. The steel furnaces in the district are consuming a heavier tonnage of pig-iron than was the case a few months back. Prices of Cleveland foundry iron are unchanged, as follow:—Delivered Middlesbrough, 62s. 6d. per ton; delivered North-East Coast, 64s. 6d.; delivered Falkirk, 62s. 3d.; delivered Glasgow, 65s. 3d. per ton. These are for No. 3 G.M.B. No. 1 quality is at a premium of 2s. 6d. and No. 4 foundry at a discount of 1s. per ton.

So far as the hematite market is concerned, there is little fresh movement, but good sales continue to be made to steelmakers. East Coast mixed numbers are still quoted at 59s., and No. 1 at 59s. 6d., but there are hints that it may not be possible to buy at these figures much longer. There have been renewed discussions among the producers with a view to attaining a remunerative level, which it is to be assumed means some increase in the price.

LANCASHIRE.—Staffordshire, Derbyshire and North-East Coast brands of No. 3 iron are quoted for delivery in the Manchester district at 67s. per ton, with Northants No. 3 at 65s. 6d., Scottish foundry at around 80s., East Coast hematite at about 75s. and West Coast at around 80s. New business is on quiet lines. Orders placed are usually for small lots for early delivery, and there appears to be little desire on the part of consumers to engage in forward business. The annual holidays in the different towns curtail business at this time of the year. There is still plenty of good machinery scrap about, and the fact that from one district near Oldham large quantities of textile-machinery scrap have been sent to the Midlands is an indication of what the supply position is in this respect. Quotations for scrap vary rather considerably, but good quality material is generally quoted in the region of 37s. 6d. to 40s. per ton, delivered, although lower rates are being indicated in some directions.

MIDLANDS.—The light-castings founders in the Midlands are still fairly busy and are taking a good aggregate of pig-iron, so that the demand so far this month has been maintained at the improved level noted in June. In the circumstances this is a not unsatisfactory position. The pig-iron makers are hoping that the activity at the light foundries will be maintained. New business is not on a large scale, as most buyers have covered their requirements. There have been no alterations in prices, Northamptonshire No. 3 being at 62s. 6d., and Derbyshire, Lincolnshire, Staffordshire and Cleveland No. 3 66s. per ton, delivered Birmingham and Black Country stations. The hematite market is quiet, the large consumers having already covered themselves ahead. West Coast hematite is quoted at the controlled level of 84s. 6d. per ton delivered, but Welsh and East Coast irons are offered at prices between 74s. 6d. and 77s. 6d. per ton. There is much competition between the Welsh and East Coast makers for any existing business.

SCOTLAND.—The Falkirk foundries reopened on Monday and had a fair amount of business on which to start, prospects over the next few weeks being a little brighter. The works in the Glasgow area are closed this week for the annual Fair holidays, which will probably extend to ten days, and possibly more in some cases. As a consequence, practically no business has been done this week. There is no change to report in prices, the official minimum of 65s. f.o.t. furnaces for No. 3 foundry still obtaining, with a minimum of 2s. 6d. extra for No. 1. No. 3 Middlesbrough is at 65s. 3d. f.o.t. Glasgow district and 62s. 3d. f.o.t. Falkirk district, with Midland irons at 2s. 3d. less respectively.

Coke.

Foundry coke is not a very active market for inland consumption, although some improvement is reported for export. This movement, however, is not yet sufficient to have any effect on prices in the home market. For delivery in Birmingham and district, best Durham foundry coke is quoted at from 36s. 6d. to 38s., with other qualities down to 34s. or 35s., Scottish low-ash coke 39s. to 40s. and Welsh coke, according to analysis, from 30s. to 45s. per ton.

Steel.

Quieter conditions have developed in the steel trade, owing to the holiday conditions ruling in several districts. In the semi-finished steel department, business has been quiet, but fresh sales of Continental semi-finished steel are reported to have been made at prices below the Continental official quotations. Business in finished steel has been moderately good and most of the British works have a fair amount of business in hand. The demand for constructional steel has improved lately, and the steel-sheet section of the industry is busier than for some time. The demand, however, for all classes of finished steel is principally from the home market, business with overseas consumers being difficult to arrange.

Scrap.

The scrap markets show little change in conditions. In the Middlesbrough area cast-iron scrap is not very active, although other classes of material have an improved tone. Prices, however, are maintained at 39s. to 41s. In South Wales heavy cast iron still meets with a fair demand and is firm at 43s. to 44s. Light cast scrap remains a little slow at 38s., and good cast-iron machinery scrap for foundry purposes has a limited sale at 48s. to 50s. In the Midlands, also, cast-iron scrap has a limited sale, but the demand is consistent, and prices vary very little. Heavy machinery metal in cupola sizes is offered at 47s. 6d., good heavy pipe and plate scrap at 40s. to 42s. 6d., and clean light metal at 37s. 6d., delivered. The holidays have curtailed business in Scotland, but there is no change in prices at 48s. 6d. to 50s. for heavy machinery cast iron in pieces not exceeding 1 cwt., and 44s. to 45s. for ordinary cast iron to the same specification, delivered works.

Metals.

Copper.—Fluctuations in prices this week have not been wide, market conditions generally being much steadier. At the moment there appears to be a lull in the demand, many consumers having covered their requirements. For the time being the tone of the market is likely to be steady.

The week's prices have been as follows:—

Cash.—Thursday, £38 3s. 9d. to £38 5s.; Friday, £38 5s. to £38 6s. 3d.; Monday, £38 1s. 3d. to £38 2s. 6d.; Tuesday, £38 7s. 6d. to £38 8s. 9d.; Wednesday, £38 11s. 3d. to £38 12s. 6d.

Three Months.—Thursday, £38 7s. 6d. to £38 8s. 9d.; Friday, £38 8s. 9d. to £38 10s.; Monday, £38 5s. to £38 6s. 3d.; Tuesday, £38 11s. 3d. to £38 12s. 6d.; Wednesday, £38 15s. to £38 16s. 3d.

Tin.—The tone of the tin market is still not too good and irregularity is likely to be seen for some little time yet. Business with consumers has been irregular, a moderate demand being reported from time to time in America, but rather quieter conditions on the whole prevailing in this country and on the Continent. Messrs. Rudolf Wolff & Company, in their weekly report, state that the comparative quietness which this market has recently experienced must be largely ascribed to the unsettlement created by the heavy fluctuations of the dollar exchange, and to the uncertainties which surround the financial and economic situation generally, and also to reports that certain quantities of tin were in course of being liquidated by pool interests, which created some apprehension as to what quantities would be involved in the near future and in consequence of which buyers adopted a cautious attitude, awaiting fresh developments.

Daily quotations:—

Cash.—Thursday, £214 10s. to £214 15s.; Friday, £214 10s. to £214 15s.; Monday, £212 12s. 6d. to £212 17s. 6d.; Tuesday, £215 7s. 6d. to £215 10s.; Wednesday, £216 10s. to £216 15s.

Three Months.—Thursday, £214 10s. to £214 15s.; Friday, £214 5s. to £214 10s.; Monday, £212 7s. 6d. to £212 10s.; Tuesday, £215 5s. to £215 10s.; Wednesday, £216 5s. to £216 10s.

Spelter.—Business with consumers in this country has fallen off slightly, which, perhaps, must be expected at this period of the year. On the whole, consumption recently has been fairly good, considering the poor rate of activity in the galvanising industry. The Zinc Cartel has raised the production quota by 5 per cent. to 50 per cent., but this action should not affect the market, as production will still remain below the level of consumption.

Price fluctuations:—

Ordinary.—Thursday, £17 18s. 9d.; Friday, £17 15s.; Monday, £17 15s.; Tuesday, £18; Wednesday, £18 2s. 6d.

Lead.—Buying for consumption shows no improvement, and the market generally is dull. Fair sales have been made this week, however, and prices have appreciated.

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £13 6s. 3d.; Friday, £13 5s.; Monday, £13 7s. 6d.; Tuesday, £13 10s.; Wednesday, £13 12s. 6d.

Company Meeting.

William Beardmore & Company, Limited.

The annual meeting of Messrs. William Beardmore & Company, Limited, was held in London last week. MR. H. A. REINCKE (chairman and managing director), who presided, said that there had been a trading loss on operating departments of £99,184 in 1932, which included a loss of £26,000 at Parkhead, £15,000 at Dalmuir, and £36,000 in the Diesel department. These losses were a matter of much regret to the directors, but it must be borne in mind that business throughout the world had been beset with serious difficulties. The heavy trades in this country had been hit harder than any other business activities in Great Britain, and their company had not escaped the common trouble. No one familiar with the shipbuilding industry would be surprised at the fact that the marine-engine shops at Dalmuir had been unable to absorb their charges with the small amount of work which they had been able to obtain. It was a disappointment that the results at Parkhead for 1932, as compared with 1931, did not show an improvement, but the reason was to be found in the fact that the 1931 Admiralty building programme was postponed, thus seriously affecting the volume of work passing through the shops. This programme having now been embarked upon, and having been followed up so closely by the 1932 programme, the volume of Admiralty work passing through both Dalmuir and Parkhead in 1933 was considerably in excess of what it had been during any one of the three preceding years. At the beginning of the year the high-speed Diesel-engine department was removed from Parkhead to Dalmuir, where better facilities for economic manufacture existed. The results of this transfer were now beginning to be felt, as Dalmuir was getting into production and was executing orders for Diesel engines of various sizes for application at sea, on rail and on the road. The increase in the volume of work at Dalmuir and Parkhead in the new financial year brought in its train the inevitable problem of finance. It would not have been possible for the company to finance the orders received but for the willingness of the debenture holders to agree to postpone payment of interest and sinking fund in the terms of the scheme, which was approved at a meeting held on June 27, and but for certain loan facilities granted to the company by the banks. Without this measure of confidence at a moment when for the first time since 1929 the prospect appeared on the horizon of securing a volume of work commensurate with the capacity of the company's establishments, they could not have carried on.

"FULMINA" ROTARY MELTING FURNACE

— OIL FIRED —

THE IDEAL FURNACE
for melting GREY CAST IRON
MALLEABLE IRON
and STEEL ALLOYS.

Used by leading Works abroad such as :—

Messrs. Burmeister & Wain, Copenhagen.

National Radiator Company, Germany.

A/G. Skodawerke, Czecho-Slovakia.

Etabl. Alphonse BINET, France.

Altos Hornos de Viscaya, Spain.

Towarzystwo Akcyne Zakladow Staporkow, Warsaw, Poland.

Compagnia Italiana Westinghouse dei Freni, Turin, Italy,
and numerous others in all Continental countries.

Write now for particulars and references.

Sole Concessionnaire for Great Britain and Dominions :—

TH. TEISEN, *Furnace Engineer,* BIRMINGHAM.

Telephone : Mid. 5806. **Telegrams : "Tete," Birmingham.** **20A, TEMPLE STREET.**

WARNER C.B.R.
CYLINDER
PIG IRON
"The brand of proved reliability"
Supplied to specifications covering a wide range of requirements and employed by the leading Railway Co's Roll Makers and Engineering Founders.
WARNER & CO. LIMITED
CARGO FLEET
MIDDLESBROUGH

RAW MATERIALS—PRICE LIST.

(Wednesday, July 19, 1933.)

COPPER.

	£ s. d.
Standard cash	38 11 3
Three months	38 15 0
Electrolytic	41 10 0
Tough	40 0 0
Best selected	40 10 0
Sheets	68 0 0
India	50 0 0
Wire bars	42 5 0
Ingot bars	42 15 0
H.C. wire rods	44 0 0
Off. av. cash, June	36 16 1 3/5
Do., 3 mths., June	37 0 0 1/2
Do., Sttlmnt., June	36 16 3 1/2
Do., Electro, June	41 8 9 1/2
Do., B.S., June	40 3 0 1/2
Do., wire bars, June	41 17 7 1/2
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	7d.

BRASS.

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8⅞d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	8d.
Wire	8d.
Rolled metal	7½d.
Yellow metal rods	4¾d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN.

	£ s. d.
Standard cash	216 10 0
Three months	216 5 0
English	217 0 0
Bars	219 0 0
Straits (nom.)	221 0 0
Australian (nom.)	—
Eastern	218 15 0
Banca (nom.)	221 10 0
Off. av. cash, June	220 1 8
Do., 3 mths., June	219 15 7 1/2
Do., Sttlmt., June	220 2 1 1/2

SPELTER.

	£ s. d.
Ordinary	18 2 6
Remelted	18 5 0
Hard	15 10 0
Electro 99.9	20 5 0
English	18 12 6
India	17 10 0
Zinc dust	20 0 0
Zinc ashes	4 5 0
Off. aver., June	16 17 7 1/2
Aver. spot, June	16 19 9 1/2

LEAD.

	£ s. d.
Soft foreign ppt.	13 12 6
Empire	13 15 0
English	15 0 0
Off. average, June	13 8 6 1/2
Average spot, June	13 5 7 1/2

ALUMINIUM.

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	26 0 0
Do., V.M. ex-whse.	25 10 0
Rods	30 0 0

ANTIMONY.

	£ s. d.
English	37 10 0 to 40 0 0
Chinese	27 0 0
Crude	—

QUICKSILVER.

	£ s. d.
Quicksilver	8 10 0 to 9 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£6 10 0
45/50%	£12 10 0
75%	£18 2 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free of Mo.	5/6 per lb.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 0 0
Ferro-tungsten—	
80/85%	1/9 lb.
Tungsten metal powder—	
98/99%	2/– lb.
Ferro-chrome—	
2/4% car.	25 10 0
4/6% car.	21 17 6
6/8% car.	19 7 6
8/10% car.	18 17 6
Ferro-chrome—	
Max. 2% car.	30 0 0
Max. 1% car.	31 0 0
Max. 0.70% car.	42 10 0
70% carbon-free	10½d. lb.
Nickel—99.5/100%	£225 to £230
"F" nickel shot	£202 10 0
Ferro-cobalt	5/9 lb.
Metallic chromium—	
96/98%	2/8 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Heavy steel		2 5 0
Bundled steel and shrngs.	1 17 6	to 2 4 0
Mixed iron and steel	2 0 0	to 2 1 6
Heavy cast iron	2 3 0	to 2 4 0
Good machinery	2 8 0	to 2 10 0
Cleveland—		
Heavy steel		2 2 6
Steel turnings		1 11 6
Cast-iron borings		1 2 0
Heavy forge		2 10 0
W.I. piling scrap		2 0 0
Cast-iron scrap	1 19 0	to 2 1 0
Midlands—		
Light cast-iron scrap		1 17 6
Heavy wrought iron		2 5 0
Steel turnings, f.o.r.		1 5 6
Scotland—		
Heavy steel	1 18 9	to 2 0 0
Ordinary cast iron	2 4 0	to 2 5 0
Engineers' turnings		1 11 9
Cast-iron borings		1 13 0
Wrought-iron piling		2 1 3
Heavy machinery	2 8 6	to 2 10 0

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	31 0 0
Brass	20 0 0
Lead (less usual draft)	12 10 0
Tea lead	10 0 0
Zinc	12 0 0
New aluminium cuttings	74 0 0
Braziery copper	28 0 0
Gunmetal	26 0 0
Hollow pewter	135 0 0
Shaped black pewter	100 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/–
Foundry No. 3	62/6
,, at Falkirk	62/3
,, at Glasgow	65/3
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	59/6
Hematite M/Nos., f.o.t.	59/–
N.W. Coast—	
Hem. M/Nos. d/d Glas.	68/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/–
,, No. 3 fdry.	66/–
Northants forge	58/6
,, fdry. No. 3	62/6
,, fdry. No. 1	65/6
Derbyshire forge	62/–
,, fdry. No. 3	66/–
,, fdry. No. 1	69/–
Scotland—	
Foundry No. 1	67/6
,, No. 3	65/–
Hem. M/Nos. d/d	66/–
Sheffield (d/d district)—	
Derby forge	59/6
,, fdry. No. 3	63/6
Lincs forge	59/6
,, fdry. No. 3	63/6
E.C. hematite	73/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/–
Staffs fdry. No. 3	67/–
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	80/–
Clyde, No. 3	80/–
Monkland, No. 3	80/–
Summerlee, No. 3	80/–
Eglinton, No. 3	80/–
Gartsherrie, No. 3	80/–
Shotts, No. 3	80/–

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 0 0	to 9 15 0
Nut and bolt iron	6 15 0	to 7 10 0
Hoops	10 10 0	to 12 0 0
Marked bars (Staffs) f.o.t.		12 0 0
Gas strip	10 10 0	to 12 0 0
Bolts and nuts, ¾ in. × 4 in.		13 0 0
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.		8 5 0
Chequer plts.		10 7 6
Angles		8 7 6
Tees		9 7 6
Joists		8 15 0
Rounds and squares, 3 in. to 5½ in.		9 7 6
Rounds under 3 in. to ⅜ in. (Untested)	6 17 6	& up.
Flats—8 in. wide and over		8 12 6
,, under 8 in. and over 5 in.		8 17 6
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 0 0
Hoops (Staffs)	9 10 0	& up.
Black sheets, 24g. (4-t. lots)		10 0 0
Galv. cor. shts. ,,		12 10 0
Galv. flat shts. ,,		13 0 0
Galv. fencing wire, 8g. plain		14 0 0
Billets, soft	5 0 0	to 5 12 6
Billets, hard	6 12 6	to 7 2 6
Sheet bars	4 15 0	to 5 5 0
Tin bars		4 15 0

PHOSPHOR BRONZE.

Per lb. basis.

Strip	11d.
Sheet to 10 w.g.	12d.
Wire	12⅝d.
Rods	11d.
Tubes	15½d.
Castings	13d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5tbs quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	17.34
No. 2 foundry, Valley	16.50
No. 2 foundry, Birm.	13.00
Basic	17.89
Bessemer	18.89
Malleable	18.39
Grey forge	18.39
Ferro-mang. 80%, seaboard	82.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	1.86
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.60
Sheets, black, No. 24	2.25
Sheets, galv., No. 24	2.85
Wire nails	1.85
Plain wire	2.10
Barbed wire, galv.	2.35
Tinplates, 100-lb. box	$4.25

COKE (at ovens).

Welsh foundry	20/– to 22/6
,, furnace	15/– to 15/6
Durham and Northumberland—	
,, foundry	21/– to 25/–
,, furnace	13/3
Midlands, foundry	—
,, furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		17/3 to 17/6
,,	28×20	,,	34/6 to 35/–
,,	20×10	,,	24/9 to 25/3
,,	18½×14	,,	18/– to 18/3
C.W.	20×14	,,	16/– to 16/6
,,	28×20	,,	33/3 to 33/6
,,	20×10	,,	22/9
,,	18½×14	,,	16/6

SWEDISH CHARCOAL IRON & STEEL.

	£ s. d.	£ s. d.
Pig-iron	£6 0 0	to £7 0 0
Bars-hammered, basis	£16 0 0	to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0	to £16 0 0
Blooms	£10 0 0	to £12 0 0
Keg steel	£30 0 0	to £31 0 0
Faggot steel	£18 0 0	to £23 0 0
Bars and rods dead soft, st'l	£10 0 0	to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
July	13 ..	38	3	9	dec.	7/6
,,	14 ..	38	5	0	inc.	1/3
,,	17 ..	38	1	3	dec.	3/9
,,	18 ..	38	7	6	inc.	6/3
,,	19 ..	38	11	3	,,	3/9

Electrolytic Copper.

		£	s.	d.		
July	13 ..	41	15	0	dec.	5/-
,,	14 ..	41	10	0	,,	5/-
,,	17 ..	41	10	0	No change	
,,	18 ..	41	15	0	inc.	5/-
,,	19 ..	41	10	0	dec.	5/-

Standard Tin (cash).

		£	s.	d.		
July	13 ..	214	10	0	dec.	65/-
,,	14 ..	214	10	0	No change	
,,	17 ..	212	12	6	dec.	37/6
,,	18 ..	215	7	6	inc.	55/-
,,	19 ..	216	10	0	,,	22/6

Tin (English ingots).

		£	s.	d.		
July	13 ..	215	5	0	dec.	75/-
,,	14 ..	215	5	0	No change	
,,	17 ..	213	5	0	dec.	40/-
,,	18 ..	216	0	0	inc.	55/-
,,	19 ..	217	0	0	,,	20/-

Spelter (ordinary).

		£	s.	d.		
July	13 ..	17	18	9	dec.	5/-
,,	14 ..	17	15	0	,,	3/9
,,	17 ..	17	15	0	No change	
,,	18 ..	18	0	0	inc.	5/-
,,	19 ..	18	2	6	,,	2/6

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
July	13 ..	20	5	0	dec.	5/-
,,	14 ..	20	0	0	,,	5/-
,,	17 ..	20	0	0	No change	
,,	18 ..	20	5	0	inc.	5/-
,,	19 ..	20	5	0	No change	

Zinc Sheets (English).

		£	s.	d.		
July	13 ..	26	0	0	No change	
,,	14 ..	26	0	0	,,	,,
,,	17 ..	26	0	0	,,	,,
,,	18 ..	26	0	0	,,	,,
,,	19 ..	26	0	0	,,	,,

Lead (English).

		£	s.	d.		
July	13 ..	15	0	0	No change	
,,	14 ..	14	15	0	dec.	5/-
,,	17 ..	14	15	0	No change	
,,	18 ..	14	15	0	,,	,,
,,	19 ..	15	0	0	inc.	5/-

Imports and Exports of Iron and Steel Castings, etc., in June and the six months 1933, compared with June and the six months 1932.

	June, 1932.	June, 1933.	Six months, 1932.	Six months, 1933.	June, 1932.	June, 1933.	Six months, 1932.	Six months, 1933.
Imports.	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Pipes and Fittings, Cast	274	43	1,715	705	4,953	1,307	30,340	13,179
Castings, in the Rough, Iron	44	—	524	44	869	15	9,267	1,680
,, ,, ,, Steel	141	81	1,045	377	2,106	1,324	20,076	6,255
Hollow-ware, Cast, not Enamelled	2	2	7	11	222	225	653	935
,, ,, Enamelled	7	10	55	43	239	655	1,870	2,460
Exports.								
BUILDERS' CASTINGS—								
To Argentine Republic	12	5	227	74	609	384	8,443	3,221
,, Irish Free State	441	344	2,160	1,842	19,635	15,249	96,417	75,605
,, British South Africa	85	189	806	947	3,200	7,995	28,843	38,993
,, ,, India	74	84	484	497	2,083	2,736	16,724	17,496
,, New Zealand	27	10	139	153	1,045	973	7,131	7,748
Total (including other countries)	924	1,042	5,896	5,811	39,649	44,504	244,678	235,359
PIPES AND FITTINGS—CAST—								
To Argentine Republic	87	369	1,131	869	1,070	3,739	12,183	9,465
,, Irish Free State	457	795	3,981	3,167	5,859	10,092	54,800	39,387
,, British South Africa	210	2,195	2,580	4,727	3,275	16,820	31,903	42,066
,, ,, India	70	161	608	677	1,452	3,578	9,877	11,366
,, ,, Malaya	192	16	1,460	254	2,054	356	14,846	3,001
Total (including other countries)	5,405	7,492	35,362	38,144	59,664	74,978	367,083	366,869
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	206	343	1,206	1,623	7,933	11,268	43,502	51,774
,, Enamelled	44	55	397	385	4,458	4,377	33,831	29,513
CASTINGS, in the rough—								
Iron	130	68	505	495	4,410	2,328	19,486	17,222
Steel	45	111	431	518	2,667	4,027	18,476	19,859

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

FOUNDRY Foreman desires change: automobile and general engineering. Grey iron and non-ferrous. Accustomed fine limits and to getting results from all methods, machine and loose pattern. Technically trained. Age 43. Present firm 9 years. Moderate salary.—Box 468, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

BRASSFOUNDRY Moulder wanted for Holland. Those preferred who are acquainted with founding phosphor-bronze, hollow or solid, bars in quoquilles (steel forms), size 50 cm. Founding wet as well as dry.—Write to A.M.B. 153, c/o N.V. RUDOLF MOSSE, Amsterdam C., Holland.

FOUNDRY Superintendent with thorough knowledge of light and heavy green-sand moulding, both plate and loose, also dry-sand. Must have first-class practical knowledge of metal mixtures and cupola practice. Northern Ireland.—State qualifications, age and salary expected, to Box 466, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOREMAN requires similar position or as Assistant Foreman. Engineering, machine tool and millwright castings, cupola practice, high-duty cast iron; accustomed to systems of payment by result. (217)

FOUNDRY Foreman or Assistant Foreman; position required by practical man with sound experience on general engineering, ferrous and non-ferrous, machine-moulding, and special knowledge of pipe-founding. Good technical knowledge. (218)

YOUNG Metallurgical Chemist, four years' laboratory and practical steel-foundry experience, desires position. Has been engaged on steel-foundry, iron-foundry, general metallurgical and laboratory work. (219)

SITUATIONS VACANT AND WANTED—*Contd*

AGENT or Representative requires position, university-trained. Metallurgical experience as chief chemist and several years' experience as agent for first-class iron company. Excellent connection with foundries, especially Midands and Yorkshire. (220)

METALLURGICAL Chemist with sound laboratory and works experience with high-class firm desires position; technical, works, or as sales representative. (221)

MACHINERY.

FOUNDRY Transverse Bar-Testing Machine by Avery, for 2-in. x 1-in. Bars, 1 to 3 ft. long, calibrated up to 40 cwts., with deflection scale; in good working order. Price £30 or nearest offer.—HARTLEY, SONS & COMPANY, Engineers, Etruria.

PNEUMATIC MOULDING MACHINES

No. 9 "Ajax" Jolt Turnover.
"Wallwork" Squeezer, 17½-in. x 12½-in. boxes.
"Tabor" Portable Jolt Rollover.
Four No. 1 Britannia Jolters.

HAND MOULDING MACHINES

Eight Standard-size Adaptables with Tail Guides.
Two Large-size Ditto, with Star handle, turnover and adaptable draw frame.
"Coventry" Headpress Squeezer Table, 22 in. x 30 in.
Four 36-in. Farwell Type Universal Squeezers.
Also
Pneulec Sand-drying Plant, 1 ton per hour, Sand Mills, Disintegrators, etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.
'Phone: Broadwell 1359.

THOS. W. WARD, LTD.

Elec. TABLE SURFACE GRINDERS, "Ever-ready," cap. 20" and 14" cup wheels.
Pneu. SAND MOULDING MACHINE, admits boxes 16" x 16" x 6".
Vert. Spindle MOULDER and SHAPER, table 24" sq.
3 LANCS BOILERS, 30' x 8', 140 lbs. w.p.
New VERT. C.T. BOILER, 7' 6" x 3' 3", 100 lbs. w.p.
Write for "Albion" Catalogue.
'Grams: "Forward." 'Phone: 23001 (10 lines).
ALBION WORKS, SHEFFIELD.

MISCELLANEOUS.

TO ANY FOUNDRY.—A Pair of Neild Safety First Boots (Prov. Patent No. 8580) will be sent on APPRO. Specially designed to protect from Molten Metal, Sand, etc., and are approved by H.M. Factory Inspectors.—NEILD, Hough End, Bramley, Leeds.

MISCELLANEOUS—*Continued.*

BRITAIN'S BEST CRUCIBLE stocked and distributed by WILLIAM OLSEN, LIMITED, Hull. Write for terms. Also General Foundry Supplies. "The right articles at the right prices."

PUBLICATION.

RYLAND'S DIRECTORY of the Coal, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades. A new edition will be going to press soon. *Write now* for full particulars and advertisement rates.—INDUSTRIAL NEWSPAPERS, LIMITED, 49, Wellington Street, Strand, London, W.C.2.

'Phone: 287 SLOUGH

HAND MOULDING MACHINES

Six Standard "Adaptables"	£12 each
24"×30" Darling & Sellars turnover	£15
Two 18"×16" Coventry HEADRAM squeezers	£18 each

PNEUMATIC MACHINES

24"×18" Tabor rollover, portable	£55
30"×20" Macdonald jolt rollover...	£60
20"×16" Macdonald jolt rollover...	£40
Britannia No. 0, 1 and 2 jolters ...	
No. 20 Macdonald plain jolter with 90"×90" table, jolts 8 tons	£160

AIR COMPRESSORS ALL SIZES IN STOCK.

Every Machine overhauled and retested.

BUY FROM ME AND SAVE MONEY!

ALEX. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD, SLOUGH

GET DOWN YOUR COSTS
by using
COLBOND
THE IDEAL BONDING MATERIAL
at **£7 10s.** per ton
our Works London.
BUY A SAMPLE CWT. TO-DAY
at **11s. 6d.** delivered and
SEE.
Particulars from:
COLBOND,
24, Martin Lane, Cannon St., London, E.C.4.
Telephone: Sloane 4862.

FERRO ALLOYS
ALL GRADES, IN POWDER, OR LUMPS FROM STOCK.

FOUNDRY SUPPLIES
FOR IRON OR STEEL.

REFRACTORIES, LADLES, ELECTRODES, ORES AND MINERALS.

WATSONS (Metallurgists) LTD.
Head Office: LANCASTER STREET, SHEFFIELD;
Works: PLATT STREET, NEEPSEND, SHEFFIELD.

CASTINGS
FOR ENGINEERS, MOTOR TRADES, &c.

"STAR FOUNDRY"
Birmingham Street, WILLENHALL, STAFFS.
Telephone: No. 25, WILLENHALL.
Telegrams: "STAR FOUNDRY, WILLENHALL."

Castings Sand-Blasted.

WILLIAM HARPER, SON & Co. (WILLENHALL) Ltd.
Malleable and Soft Grey Ironfounders.